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RELATION OF THE INTERIOR CONDITION OF WATER MAINS TO THE COEFFICIENT OF ROUGHNESS[1]

BY A. T. CLARK[2]

The formula developed by Chezy in 1775 has been the basis for practically all formulas devised for the flow of water in pipes since that time. "R" and "S" were removed from the radical and given almost every exponent available, as it was soon realized that the velocity did not vary directly as the square root of either of these elements. The expression for the coefficient "C" was also modified by Kutter as it was found that its variation was not uniform. Kutter produced an elaborate formula for "C" involving another variable coefficient "n" and assigned values for that coefficient for substitution in Chezy's formula, making "C" vary.

Weston in his book of tables, brought out in 1896, states as follows:

> "About 20 years ago, when the author first commenced to make practical application of hydraulic formulas, he was unable to find one for calculating loss of head due to the friction of water flowing in pipes, that he had not heard criticized more or less unfavorably by hydraulic engineers."

All of this happened 50 to 150 years ago. Today it may seem strange that, with the vast number of pipe lines in existence and the length of

[1] Presented before the New York Section meeting, October 3, 1929.

[2] Chief Engineer, Community Water Service Company, New York, N. Y.

time that they have been in service, some clear cut and universal solution has not been devised for this problem. This is no doubt due to the fact that any problem having so many variable factors cannot produce an exact mathematical result. This condition was aptly described by Horton when he said, "that the ancients knew more about astronomy before the invention of the telescope than we know about hydraulics today."

If we analyzed Chezy's formula $V = C\sqrt{R\,S}$ we find that "C" is a coefficient, originally thought to be constant, but now known to vary with the functions of the slope, the hydraulic radius, the velocity and with some factor, representing the retarding influences in the pipe.

"R" and "S," as previously stated, have been removed from the radical and as stated by Hazen, "in recent years the range of exponents is well taken up and any exponent that may be selected will be found to have been already used by someone."

The Moritz formula referred to by Scobey[3] is in reality the old Lampe formula. In a similar way the formula proposed by Scobey in 1920 had been previously reached by Hazen in 1901 by a reconsideration of hydraulic data presented by Fenkell.[4]

The variations of Chezy's original formula have been variously criticized, in that the velocity or flow does not vary directly as the $\sqrt{R}$ or $\sqrt{S}$. Kutter's "n" while fairly applicable to open channels does not fit pipes under pressure. Weston's tables were apparently built up by gradually increasing the coefficient "C" up to 112 for pipes up to 12 inches in diameter, and the variation stopped there. Accordingly Weston's tables tend to show deficient flows for larger sized pipes. A comparison for a 36-inch main as between Weston's and Williams and Hazen tables indicate a deficiency of approximately 15 percent in the flow indicated by the former.

Williams and Hazen's tables, which have survived since 1905 and for which a slide rule has been developed, apparently give a value which is too high for 6-, 8-, and 10-inch pipe and too low for 30-, 40- and 48-inch pipe. This however agrees with the idea upon which these tables are based, that is, to approximate as closely as possible the means of actual results within the ability of the formula.

From Williams and Hazen's tables it would be assumed that the carrying capacity of a main varied with its age only. These tables

[3] U. S. Department of Agriculture, Bulletin No. 852.

[4] Journal Assoc. Eng. Socs., Vol. 26, page 163.

carry at the top of each column of loss of head, the age of the pipe at which the coefficient might be assumed to apply.

Twenty-eight (28) tests[5] on pipe varying from 4 to 36 inches indicate that there is no such general variation in the value of the coefficient due to age alone.

These few references are given merely as an indication of the difficulties encountered in attempting to assign definite fixed mathematical terms to a problem in which it is practically impossible to measure or record all the variations.

For ordinary application other than laboratory work, the percentage increase in flow due to cleaning a main may be indicated almost equally well by any of the formulas. It would merely mean that we have been using a different "yard stick" for the expression of the condition existing within the pipe. It is not to be assumed, therefore, that none of these formulas is good. They are all good and the result obtained by any one formula for ordinary application is practically as good as that obtained by another. The different results obtained, however, should not be compared in a given problem.

It would simplify the study if one formula, with varied coefficients best suited to apply to the surface condition, could be used for all pipes rather than a separate formula for each different material such as wood, concrete, iron or other pipe forming material. As stated by Hazen, "There is a distinct advantage in using only one formula, for one becomes thoroughly accustomed to it, accumulates his data in its terms, can much better judge all varying conditions and is less likely to make errors in its application."

Apparently there is no method of converting interior or surface conditions of water mains into rare and exact coefficients simply by turning the pages of a book. There is, however, in almost every day operation the possibility of encountering some of the elements entering into this study of which we may take advantage if proper and sufficient records of these occurrences are noted and kept.

Accordingly this paper is submitted, not with the idea of being an attempt to transform the field into a laboratory, but, rather, of bringing to the attention of those operators engaged at times in this class of work, the varied elements of the picture, in order that they may observe and collect such data as may better enable them to apply this information intelligently to any of the pipe flow formulas. In addition, these data will be of much value and save considerable

[5] Jour. A. W. W. A., Vol. 5, No. 2, page 152.

time and expense, when and if the services of a consulting engineer become necessary.

Briefly these elements as they may occur are as follows:

1. Record of deficient pressure and flow.
2. Nature of water handled.
3. Record of pitometer or pitot meter survey or other similar studies to determine the cause of the deficiencies.
4. Record of the correction of these deficiencies through cleaning or otherwise.
5. Record of the corrected pressure and flow, and
6. Periodic subsequent tests of the main cleaned, to determine the rate of loss of efficiency or loss in the value of the coefficient "C."[6]

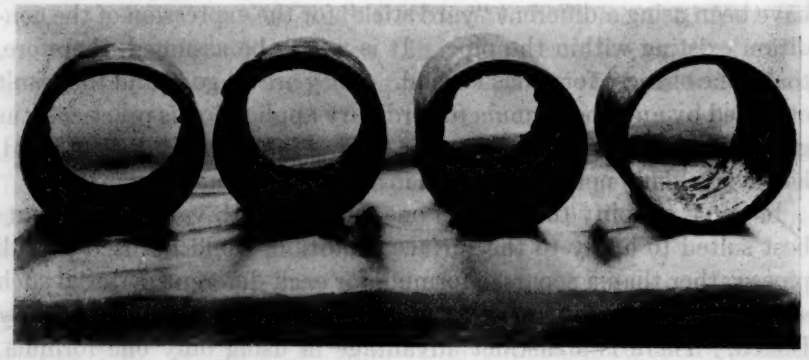

FIG. 1

Inasmuch as the maintenance or the restoration of full capacity flow in pipe lines is a subject that has forced itself upon the attention of those engineers who are interested or engaged in the transmission of water, a few examples of the conditions existing within a water main may be of interest.

Figure 1 shows the condition in four different 6-inch mains. Three of the sections show the natural nodulated condition existing in the main. The fourth section shows the surface condition after cleaning. This section of pipe is available for inspection. In this sample, it should be noted that the coating material was not properly applied and in spots left a comparatively rough surface. Mr. Nicholas S. Hill reports that a variation in the coefficient of 30 percent may be effected by the manner in which the dipping of a 6-inch pipe is done, that is, whether the surface is left smooth or corrugated.

[6] Jour. A. W. W. A., Vol. 21, No. 6.

Figure 2 shows the interior of a badly corroded and silted pipe line.

Deflection or velocity curves obtained before and after cleaning, in a uniformly laid, straight section of pipe, from actual test are shown in figure 3. Note variation in pipe coefficient $\left(\frac{Vm}{Vc}\right)$ and velocity at pipe surface.

The size and spacing of nodules observed in a 16-inch main of The New Rochelle Water Company at Dobbs Ferry, are shown in figure 4.

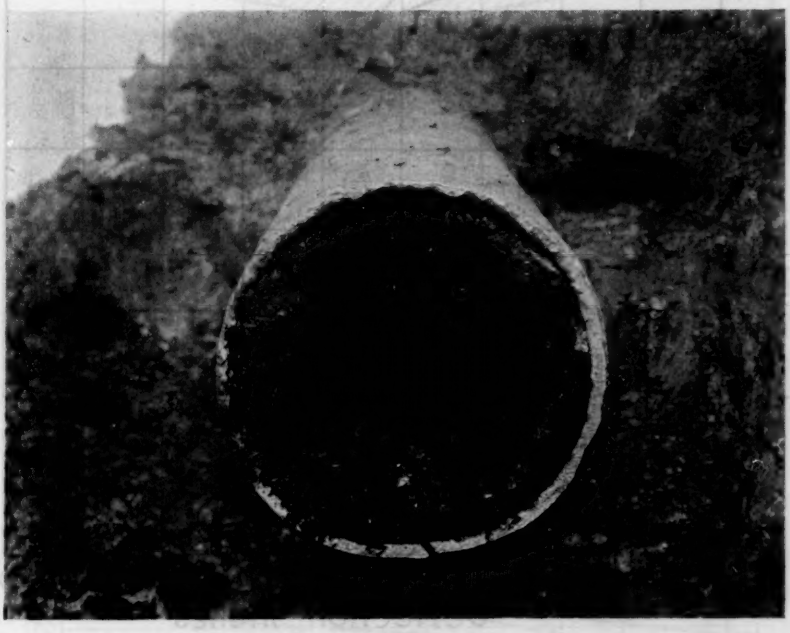

FIG. 2

These nodules were between $\frac{1}{8}$- and $\frac{3}{8}$-inch in height, between $1\frac{1}{4}$- and $1\frac{1}{2}$-inch through at the base by about $\frac{3}{4}$- to $1\frac{1}{4}$-inches in length. There were numerous small nodules almost circular in form about $\frac{1}{8}$-inch in diameter and $\frac{1}{8}$-inch high. There was, however, no general deposit or growth covering the entire surface of the pipe. Nodules were spaced on an average of about $1\frac{1}{2}$-inch centers crossways of the main and about $\frac{3}{4}$-inch centers in the line of flow. The upstream face of all nodules was about 60°, smooth and slightly rounding at the top. The downstream face flattened out considerably to about a 30° angle

and the surface was rippled parallel with the base or lengthways of the nodules. It is interesting to note in this connection that for the same slope and the same rate of flow, a 12-inch water main with a coefficient of "C" equal to 100, would have fulfilled the hydraulic conditions found in this 16-inch main before cleaning. This may or may not

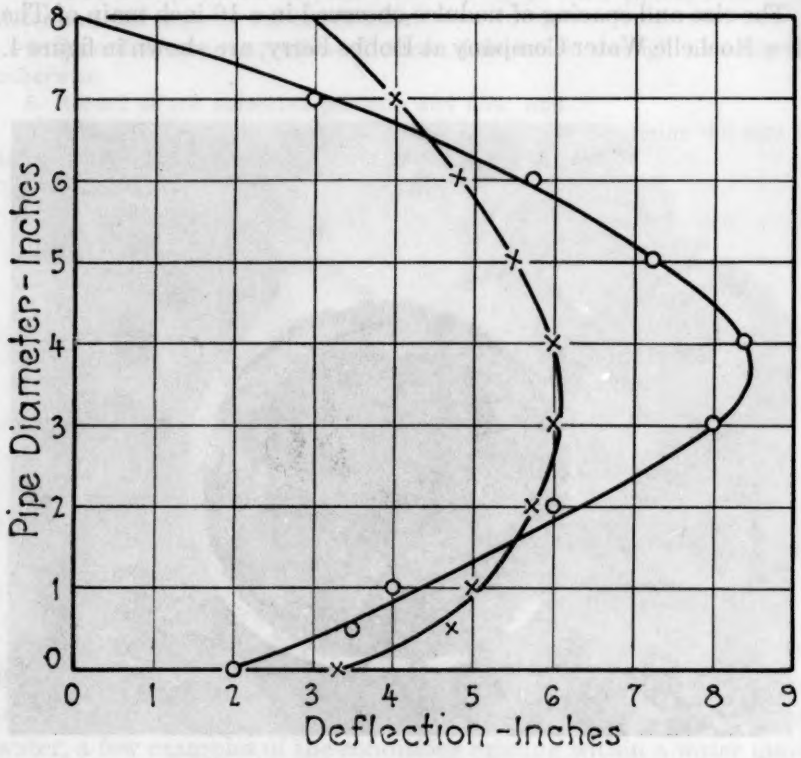

FIG. 3. DEFLECTION CURVES, 8-INCH PIPE (BEFORE AND AFTER CLEANING)

	Before	*After*
Pipe Coefficient	0.750	0.866
C in Chezy Formula	63.0	103.5

indicate that a nodulation, under certain rates of flows, might be considered to reduce the available effective or working area of a pipe to five times the height of the nodule. Or, stating it another way, a reduction of 6 percent in area by nodulation reduced the effective area at least 44 percent and the carrying capacity approximately 50 percent.

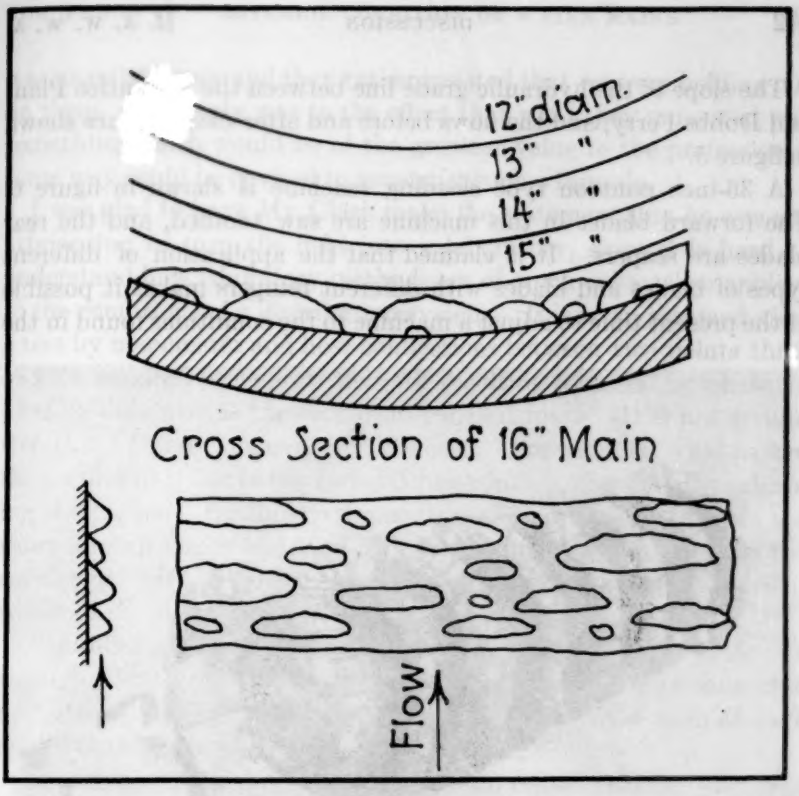

FIG. 4. SKETCH OF NODULATION IN PIPE LINE

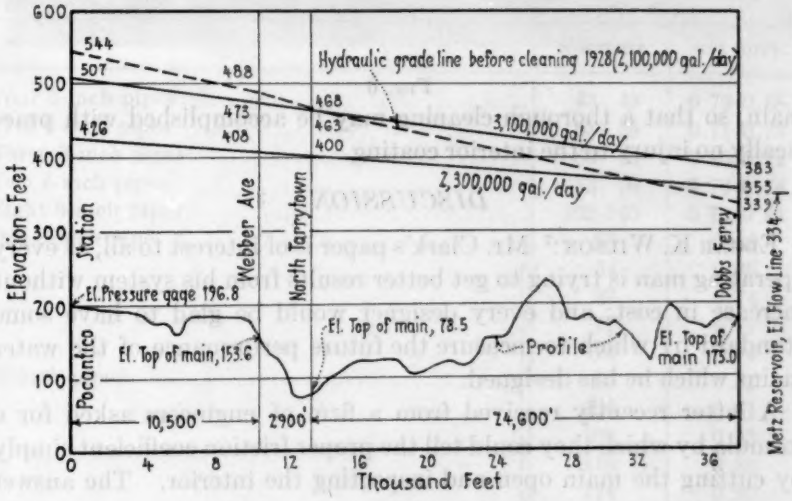

FIG. 5. PROFILE AND HYDRAULIC GRADE LINE OF 16-INCH CAST-IRON MAIN NEW ROCHELLE WATER COMPANY—POCANTICO DIVISION, N. Y.

The slope of the hydraulic grade line between the Pocantico Plant and Dobbs Ferry, and the flows before and after cleaning, are shown in figure 5.

A 36-inch pontoon type cleaning machine is shown in figure 6. The forward blades in this machine are saw toothed, and the rear blades are scapers. It is claimed that the application of different types of blades and blades with different tempers makes it possible at the present time to adjust a machine to the conditions found in the

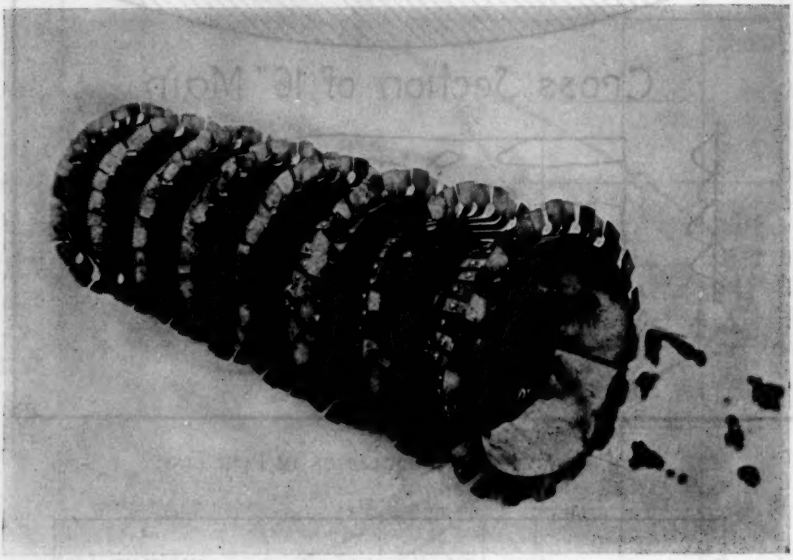

FIG. 6

main, so that a thorough cleaning may be accomplished with practically no injury to the interior coating.

DISCUSSION

EDGAR K. WILSON:[7] Mr. Clark's paper is of interest to all, as every operating man is trying to get better results from his system without increase in cost; and every designer would be glad to have some standard by which to measure the future performance of the water mains which he has designed.

A letter recently received from a firm of engineers asked for a formula by which they could tell the proper friction coefficient simply by cutting the main open and inspecting the interior. The answer

[7] Chief Engineer, The Pitometer Company, Engineers, New York, N. Y.

was unsatisfactory and they rather insisted that we were holding out on them. My reply was to the effect that what they requested was something which would be of the greatest value to the profession if some way could be devised to construct such a formula.

I was glad to have Mr. Clark make the statement that he was not attempting to turn the field into a laboratory, since it is hard to understand how laboratory methods are of much value when applied to the conditions of a distribution system. It is often assumed after a test by manometer and hose connections between two points three or four hundred feet apart, that the resulting formula, by whatever formula obtained, is the coefficient for that main. It is not certain that this is by any means always the case. For instance, what part of the coefficient is due to the varied debris which is often found on cleaning the mains? Do these extraneous materials happen to be in the short stretch under test, and if so what effect do they have on the coefficient? If they are elsewhere, can we assume that the coefficient will hold throughout the whole length of pipe?

A number of years ago a series of loss of head tests were made in a western city, using short lengths of main, and a manometer connected up by rubber hose to piezometers set at the center of the main at each end of the stretch.

In each case the ratio between mean and center velocity—the pipe coefficient—was computed. The following table shows the results at a velocity of 3 feet per second:

	W-H COEFF.	PIPE COEFF.
Four 6-inch pipes	43- 49	0.79–0.68
Five 6-inch pipes	53- 59	0.71–0.78
Three 6-inch pipes	60- 64	0.80–0.72
Two 6-inch pipes	73- 76	0.76–0.74
Eight 6-inch pipes	102–140	0.79–0.84
One 8-inch pipe	98	0.82
12-inch pipes	54	0.69
	67	0.74
	77	0.77
	74	0.74
	83	0.81
	104	0.81
	109	0.83
	116	0.83
	124	0.80
14-inch pipe	83	0.75

It will be seen that there is some relation between the Williams Hazen formula and the pipe coefficient, although the number of instances shown is too small for any definite conclusions. Since a pipe coefficient of about 0.85 is normal for a clean straight pipe, it is evident that for the upper brackets of the friction coefficient the spread between the pipe coefficients is very small, probably not much more than 0.05 for all friction coefficients above 100.

PEAK 24-HOUR WATER CONSUMPTIONS IN SEVERAL CITIES IN 1929

By A. V. Ruggles[1]

The following letter was sent to a number of cities last summer by the American Water Works Association.

All signs fail in a dry time and this is a dry season this year. We have been informed that in Detroit on Saturday, July 27, 348,000,000 gallons were pumped, about 70,000,000 gallons more than their previous big day, which was in 1928. According to the papers Chicago and Baltimore have also been breaking records on pumpage and the same is likely to be true in many places.

We would be glad to know if you have established any new records this year, for maximum consumption of water for a day, a week, or a month, compared with previous maximum figures. If population figures are also sent in, interesting comparisons of per capita consumption figures could be made. We believe that statistics of this kind would be of interest for publication in The Journal.

A number of replies were received, some transmitting figures in tabular form which are of interest and are given herewith. In general, average consumption figures increase from year to year with growth of population, so the writer made up figures for per capita daily consumption from the returns in order to show more definitely the effect of the hot weather in 1929.

The population data in table 1, prepared by the writer, are in part as estimated by the water officials of these cities sending in the water consumption figures, and in part as adapted by the writer from estimates in the 1929 World Almanac for July 1, 1928 populations. In all cases the population figures are uncertain, as it is nearly ten years since the last Federal census.

Table 2 contains maximum daily consumption figures, in gallons and in gallons per capita, in 1929, in 1928 and some earlier figures where they have not been equalled since.

[1] Assistant to Secretary, American Water Works Association, New York, N. Y.

Extracts from the replies giving figures which could not be included in table 2 are presented below.

Allentown, Pa. W. R. Schnable, Superintendent. Since July 1, 1929, had 17 days when pumpage exceeded 16 m.g.d.

Baltimore, Md. E. G. Rost, Water Engineer. Figures include water distributed in Anne Arundel and Baltimore Counties, as well as in the City of Baltimore.

TABLE 1

CITY	APPROXIMATE POPULATION SUPPLIED					
	1920	1925	1926	1927	1928	1929
Allentown, Pa	73,502				100,600	104,000
Baltimore, Md	733,826				874,000	884,000
Billings, Mont	15,100			17,500	17,700	18,000
Chicago, Ill	2,701,705				3,157,400	3,214,400
Dallas, Tex	158,976				239,900	250,000
Detroit, Mich	993,678			1,711,770	1,814,350	1,916,930
Jackson, Miss	22,817					24,000
Louisville, Ky	234,891	306,000	310,000	312,000	315,000	330,000
Milwaukee, Wisc	457,147		569,050			625,000
New York, N. Y.		5,542,000	5,641,000	5,752,000	5,843,000	5,980,000
Parkersburg, W. Va	20,050			27,790	28,900	30,000
Philadelphia, Pa	1,823,779			2,060,000	2,088,000	2,108,000
Portland, Me						
Providence, R. I.	267,918	312,615	314,801	321,078	327,393	333,620
St. Louis, Mo	772,897		869,370		901,530	917,607
Trenton, N. J	119,289			136,540	139,000	141,460
Washington, D. C.	437,572				552,000	566,300

Billings, Mont. J. F. Willett, Superintendent.

	1927 *gallons*	1928 *gallons*	1929 *gallons*
July	104,703,000	94,302,400	117,915,400
August	83,864,400	99,500,600	122,202,000
	188,567,400	193,803,000	240,117,400

Population supplied in 1927, 17,500, in 1928, 17,700 and in 1929, 18,000. This excess water was used in irrigation as there is little variation in our pumping comparing the same months from year to year, from October to May.

TABLE 2

Maximum daily consumption figures

CITY	DATE OF LETTER	MAXIMUM DAILY CONSUMPTION										PER CENT INCREASE IN G.P.C.D. OVER	
		1928			Before 1929			1929 to date of letter					
	1929	Date	M.G.D.	G.P.C.D.	Date	M.G.D.	G.P.C.D.	Maximum in history	Date	M.G.D.	G.P.C.D.	1928 maximum	Previous maximum
Allentown, Pa	Sept. 13		16.2	161	1928	16.2	161	Yes	July 8	17.3	166	3.1	3.1
Baltimore, Md	Sept. 10	July 23	135.5	155	July 23, 1928	135.5	155	No	Aug. 9	134.0	152	−1.9	−1.9
Chicago, Ill	Oct. 8	Aug. 9	1,151.6	365					July 31	1,195.6	372	1.9	
Dallas, Tex	Oct. 1	Aug. 22	26.9	112	Aug. 22, 1928	26.9	112	Yes	Aug. 7	32.2	129	15.2	15.2
Detroit, Mich	Sept. 9	Aug. 8	296.3	163	Aug. 8, 1928	296.3	163	Yes	Sept. 4	361.6	189	16.0	16.0
Louisville, Ky	Sept. 14	Jan. 3	65.3	207	Jan. 3, 1928	65.3	207	Yes	Aug. 22	65.6	199	−3.9	−3.9
Milwaukee, Wisc	Sept. 7				July 20, 1926	107.6	189	Yes	Sept. 3	119.7	192		1.6
New York, N. Y	Sept. 16	July	954.2	163	June 5, 1925	981.3	177	Yes	June 18	1,036.6	173	6.1	−2.3
Parkersburg, W. Va	Sept. 12	Aug. 12	3.4	118	Aug. 12, 1928	3.4	118	Yes	July 26	3.7	123	4.2	4.2
Philadelphia, Pa	Sept. 21	Aug. 3	418.0	200				No	July 31	405.0	192	−4.0	
Providence, R. I	Sept. 12	Oct. 17	32.8	100	Oct. 17, 1928	32.8	100	Yes	June 17	33.0	99	−1.0	−1.0
St. Louis, Mo	Sept. 21		146.5	162	Aug. 1926	159.9	184	Yes		161.2	176	8.6	−4.3
Washington, D. C	Sept. 9	July 31	81.2	147					July 31	102.8	181	23.1	

Chicago, Ill. L. D. Gayton, City Engineer.

	gallons
Total pumpage July, 1929	34,174,330,000
Total pumpage July, 1928	32,384,900,000
Total pumpage August, 1929	33,895,990,000
Total pumpage August, 1928	33,315,730,000

TABLE 3

Department of Water Supply, Detroit, Mich. Water consumption daily average

MONTH	1927	1928	PER CENT INCREASE OVER PREVIOUS YEAR	1929	PER CENT INCREASE OVER PREVIOUS YEAR
	gallons	gallons		gallons	
January	208,939,855	207,916,685	0.49*	249,767,452	20.13
February	205,636,902	212,208,715	3.2	256,087,411	20.68
March	205,268,250	208,412,855	1.53	248,451,919	19.21
April	205,225,958	204,856,033	0.18*	247,753,742	20.94
May	207,125,589	215,165,169	3.88	254,660,185	18.36
June	221,905,367	223,429,433	0.69	281,128,442	25.82
July	229,504,468	249,497,734	8.71	293,990,992	17.83
August	231,551,024	265,677,992	14.74	312,239,185	17.45
September	222,828,600	244,563,767	9.75		
October	204,435,734	237,587,694	16.22		
November	196,462,725	229,535,617	16.83		
December	202,333,137	228,727,315	13.04		
Yearly average	211,820,308	227,399,309	7.35		

* Decrease.

Average daily pumpage

	gallons	gallons per capita
July, 1929	1,102,400,000	343
July, 1928	1,044,670,000	331
August, 1929	1,093,420,000	340
August, 1928	1,074,700,000	340

Dallas, Tex. H. E. Moore, Secretary and Collector. Daily average pumpage in August, 1929 was 29,793,000 gallons.

Detroit, Mich. F. H. Stephenson, Engineer of Water System. Three big days in 1929 previous to September 9, the date of their letter, were:

	gallons
July 31, 1929	354,000,000
September 3, 1929	351,000,000
September 4, 1929	361,617,000

Table 3 gives daily average water consumption figures for Detroit for 1927, 1928 and 1929. The figures averaged 7.35 percent higher in 1928 than in 1927. For the first eight months of 1929 the percentages by which these months exceeded the corresponding months of 1928 ran from 17.45 to 25.82, averaging 20.05.

Jackson, Miss. J. H. Fewell, Superintendent. Pumpage in August, 1929, exceeded any month in the history of the plant by 13,000,000 gallons on account of the excessive drought and heat. From the population table 1 this is an increase of 17 gallons per capita daily.

Louisville, Ky. John Chambers, Chief Engineer and Superintendent.

Year	Average daily pumpage *gallons*	Maximum daily pumpage *m.g.d.*	Date
1925	41,882,080	63.01	9–4
1926	43,649,605	63.73	9–2
1927	42,010,333	58.45	9–12
1928	43,251,571	65.3	1–3
1929	43,700,000 (estimated)	65.6	8–22

Year	Population	Average daily per capita
1925	306,000	136.0
1926	310,000	141.0
1927	312,000	134.8
1928	315,000	137.0
1929	330,000	132.5

New York, N. Y. W. W. Brush, Chief Engineer, Department of Water Supply, Gas and Electricity. Tables 4 and 5 give some interesting comparative data on New York City.

Parkersburg, W. Va. George Huber, Superintendent, Department Water Works and Sewers. Highest monthly pumpage in each of the last three years:

	gallons
August, 1927	85,213,000
August, 1928	91,660,000
August, 1929	102,191,000

Highest daily pumpage:

	gallons
July 9, 1927	3,272,000
August 12, 1928	3,405,000
July 26, 1929	3,690,000

Population served 30,000.

No unusual amount or consumption this summer. Increase in amount pumped due to growth in population.

TABLE 4

New York, N. Y. Comparative data—high consumption of water

Highest daily consumption in each month from April to September, and average for each month for years 1925 to 1929. (Figures in million gallons daily.)

	HIGHEST AVERAGE									
	1925		1926		1927		1928		1929	
	Day	Month	Day	Month	Day	Month	Day	Month	Day	Month
April	807.8	761.5	836.5	804.7	866.6	810.7	842.3	808.0	915.0	833.2
May	795.3	751.2	819.2	781.9	832.5	784.6	837.6	801.7	942.2	832.9
June	981.3	836.5	877.2	796.2	872.7	815.7	875.2	817.7	1,036.6	897.9
July	894.2	814.0	969.4	838.6	970.0	841.9	954.2	850.6	1,008.9	910.6
August	882.8	816.6	923.1	836.8	869.8	806.5	935.1	854.4	957.7	888.4
September	889.8	828.6	929.3	834.6	874.9	825.6	896.3	826.6		

Highest daily consumption in each month during summer of 1929 and, for comparison, the highest daily consumption previously recorded in each corresponding month of any year since 1925, with other comparative data.

	DEPARTURE FROM ESTIMATED NORMAL	ESTIMATED POPULATION SERVED BY MUNICIPAL SYSTEM	PER CAPITA CONSUMPTION	TEMPERATURE			
				Maximum	Minimum	Mean for day	Normal mean
	M.G.D.			*°F.*	*°F.*	*°F.*	*°F.*
June, 1929, 1,036.6 m.g. on Tuesday the 18th	167	5,980,000	173	93	72	82	73
July, 1929, 1,008.9 m.g. on Monday the 29th	119	5,980,000	169	91	75	83	75
August, 1929, 957.7 m.g. on Monday the 12th	77	5,980,000	160	88	69	78	74
September,* 1929, 1,007.2 m.g. on Wednesday the 4th	127	5,980,000	168	94	73	83	
June, 1925, 981.3 m.g. on Friday the 5th	175	5,542,000	177	96	78	87	66
July, 1927, 970.0 m.g. on Friday the 15th	146	5,752,000	169	90	74	82	74
August, 1928, 935.1 m.g. on Friday the 3rd	60	5,843,000	160	90	73	82	74
September, 1926, 929.3 m.g. on Monday the 13th	108	5,641,000	165	72	60	66	68

* Records available to September 7.

Philadelphia, Pa. S. M. Van Loan, Deputy Chief. No record pumping in Philadelphia this year. Here are the hot weather peaks for the last three years:

Year	Day	Pumpage m.g.	Population
1927	July 21	402	2,060,000
1928	August 3	418	2,088,000
1929*	July 31	405	2,108,000

* Incomplete.

TABLE 5

New York, N. Y. Average daily consumption for summer months of 1929 and, for comparison, the highest average daily consumption previously recorded for each month since 1925

	DEPARTURE FROM ESTIMATED NORMAL	ESTIMATED POPULATION SERVED BY MUNICIPAL SYSTEM	PER CAPITA CONSUMPTION	TEMPERATURE			
				Maximum	Minimum	Mean for month	Normal mean
	M.G.D.			°*F.*	°*F.*	°*F.*	°*F.*
June, 1929, 897.9 m.g.d.	30	5,980,000	150	93	44	70.0	68.8
July, 1929, 910.6 m.g.d.	27	5,980,000	152	92	56	74.1	73.8
August, 1929, 888.4 m.g.d.	29	5,980,000	149	88	56	71.2	73.1
June, 1925, 836.5 m.g.d.	24	5,542,000	151	96	53	73.2	68.8
July, 1928, 850.6 m.g.d.	5	5,843,000	145	92	61	75.0	73.8
August, 1928, 854.4 m.g.d.	0	5,843,000	146	90	61	74.4	73.1

Rainfall at Battery (inches)

	TOTAL	NORMAL	NUMBER OF DAYS RAINFALL RECORDED	GREATEST IN 24 HOURS	ACCUMULATED EXCESS SINCE JANUARY 1
June, 1929	2.30	3.33	8	1.09	1.26
July, 1929	0.98	4.24	5	0.50	−2.00
August, 1929	1.45	4.33	9	0.81	−4.88
June, 1925	2.31	3.26	9	1.08	−4.43
July, 1927	5.93	4.54	11	3.00	−4.06
August, 1928	4.26	4.33	15	1.14	3.60
September, 1926	5.51	3.59	8	3.09	3.70

Providence, R. I. S. Frank Nolan, City Engineer.

Year	Maximum daily consumption		Estimated population supplied	Gallons per capita daily	
	Date	Gallons		Average for year	Maximum day
1929	June 17	33,020,390	333,620	76	99
1928	October 17	32,784,400	327,393	75	100
1927	May 28	29,897,220	321,078	71	93
1926	July 9	30,757,716	314,801	76	98
1925	May 15	30,035,931	312,615	71	96

St. Louis, Mo. G. A. Hoffman, General Superintendent of Pumping Stations. The total high service pumping for the month of August, 1929 was 4,304,000,000 U. S. gallons as compared to 4,075,000,000 gallons for August, 1928.

The corresponding average daily figures are 139 m.g. for August, 1929 and 131 m.g. for August, 1928.

Trenton, N. J. Alvin Bugbee, Superintendent.

Average pumpage at Calhoun Street Station

Million gallons daily

Month	*10 years average 1917 to 1926*	*1927*	*1928*	*1929*
January	19.3	18.3	18.1	17.3
February	20.0	17.1	18.5	17.5
March	17.6	16.1	16.6	16.3
April	16.3	15.6	15.9	15.0
May	16.2	15.5	15.3	16.2
June	16.7	16.2	15.9	17.5
July	16.5	15.6	17.2	20.2*
August	16.5	15.6	16.9	
September	16.4	15.8	16.5	
October	16.1	15.4	16.5	
November	15.9	15.3	15.8	
December	16.9	16.0	15.8	
Average	17.0	16.0	16.6	

* Maximum.

CENTRIFUGALLY SPUN REINFORCED CONCRETE PIPE AT TACOMA, WASHINGTON[1]

By W. A. Kunigk[2]

During last October the Water Division of the Department of Public Utilities of the City of Tacoma completed the installation of 14,550 feet of centrifugally spun reinforced concrete pipe, replacing an equal length of wooden pipe of the Green River gravity supply line. This pipe line provides a principal water supply for the City of Tacoma. The wooden pipe that was replaced has been in service since early spring of 1913. In the reconstruction of this pipe it was desirable to use a material more permanent than wood. Specifications were, therefore, prepared and bids invited on steel pipe and reinforced centrifugally spun concrete pipe. This particular replacement of pipe is located on the Northern Pacific Company's right-of-way between Palmer and Cumberland, paralleling the old pipe practically all the way within about eight feet, center to center.

In view of the fact that the City of Tacoma has to depend for its principal source of water supply on a single gravity pipe line 43 miles long, many precautions had to be taken during reconstruction and a number of perplexing problems have presented themselves in carrying out this program. Service had to be maintained at all hazards and the Department has for this reason carried out all reconstruction work to date by day labor. In handling the work in this manner the Department has maintained absolute control over any and all precautionary measures necessary to assure continuous water service to the City. The Department, therefore, prepared plans and specifications for delivery at the nearest spur or team track of 7542 feet of 63-inch diameter electrically welded steel pipe made up of $\frac{5}{16}$ inch plate to replace an equal length of 60-inch diameter continuous wood stave pipe and also for 7010 feet of 51-inch diameter electrically welded steel pipe of the same thickness of plate to replace an equal length of

[1] Presented before the Montana Section meeting, April 6, 1929.

[2] Superintendent, Water Division, Tacoma, Wash.

48-inch diameter continuous wood stave pipe. Under this specification the Department was to assume all responsibility for hauling of pipe, clearing of right-of-way, trenching, laying, cradling, testing, backfilling, rebuilding of telephone lines and roads, etc.

In preparing specifications for the centrifugally spun concrete pipe, inasmuch as this kind of pipe was new and untried by the City, it was desirable that the contractor should furnish a maintenance bond for a period of two years. This the contractor could not, of course, be expected to do unless he had the responsibility in laying the pipe with his own organization. The specifications for the concrete pipe provided therefore, for the manufacture of the same length and diameter of pipe as called for in the specifications for the electrically welded steel pipe; but the contractor had to assume the further responsibility of hauling, laying, cradling, testing and covering the pipe sufficiently to prevent movement on account of thermal stresses. In this case the Department agreed to clear the right-of-way, take care of the trenching, subgrading, backfilling, rebuilding of telephone lines and roads, etc.

Bids were received May 14, 1928, with the following results:

The low bid on electrically welded steel pipe was submitted by the Western Pipe & Steel Company of San Francisco, California, with the following unit prices:

7542 lin. feet 63-inch x $\frac{5}{16}$ inch Steel Pipe @ 8.64	$65,162.88
7010 lin. feet 51-inch x $\frac{5}{16}$ inch Steel Pipe @ 7.25	50,822.50
One 30-inch x $\frac{5}{16}$ inch Steel Standpipe	116.00
13 Cast Steel Manholes complete, with C. I. Cover and Fittings @ 61.50	799.50
Two Air Valve Saddles @ 26.55	53.10
Four Blow-Off Saddles @ 34.70	138.80
One 4-inch Service Connection	10.80
Three Steel Sleeves @ 17.00	51.00
Coating all above Pipe and Fittings with Hermastic by Dipping Process	6,600.00
Grand Total	$123,754.58

The low bid on centrifugally spun reinforced concrete pipe, "Hume Process," laid and tested, was submitted by the Western Concrete Pipe Company of Tacoma with unit prices as follows:

7542 lin. feet 63 inch-diam. Centrifugally Spun Reinforced Concrete Pipe @ 11.25	$84,847.50

7010 lin. feet 51-inch diam. Centrifugally Spun Reinforced Concrete Pipe @ 9.00	$63,090.00
13 Manholes, complete with Gaskets and Attachments @ 60.00	780.00
Two Air Valve Saddles and Attachments @ 25.00	50.00
Four Blow-Off Saddles and Attachments @ 35.00	140.00
One Service Connection 4-inch and Attachment	25.00
One 30-inch I. D. Centrifugally Spun Reinforced Standpipe with approved Foundation	300.00
Grand Total	$149,232.50

Our estimate for the completed job using the steel pipe was $223,938.64. Our estimate for the completed job using centrifugally spun concrete pipe was $209,806.16. Concrete pipe was used and the job was finished at an actual cost of $189,477.16.

CONCRETE PIPE SPECIFICATIONS

The concrete pipe specifications called for the pipe to be made up in 8-foot lengths with a thickness of shell for the 63-inch diameter pipe of $5\frac{1}{4}$-inch and for the 51-inch diameter pipe, $4\frac{1}{4}$-inch. For the cement used the standard requirements of the specifications of the American Society for Testing Materials, Serial Designation C9-21 were specified. No waterproofing was called for, but the contractor voluntarily agreed to furnish a cement of which not less than 90 percent would pass the 200-mesh sieve. The mix specified for the concrete to be used in pipe for heads from 10 to 50 feet was $1:2\frac{1}{2}:1\frac{1}{2}$ and for heads over 50 feet, 1:2:1 of cement, sand and gravel, respectively. These were the minimum requirements for cement content. The contractor was at liberty to increase the cement content if he so desired. The coarse aggregate was graded from $\frac{3}{8}$-inch diameter down to that of coarse concrete sand and the fine aggregate was usually made up of a mixture of about 60 percent coarse concrete sand and 40 percent of plastering sand. The maximum slump of the mix was limited to 2 inches. An actual slump from $1\frac{1}{2}$ to 2 inches was usually obtained by using approximately $3\frac{1}{2}$ gallons of free water per sack of cement.

For reinforcement cold drawn steel wire was specified that would meet the requirements of the specifications of the American Society for Testing Materials, Serial Designation A82-27, calling for an ultimate strength of 80,000 pounds per square inch. The permissible working stress for this was limited to 16,000 pounds per square inch.

Tests showed that the ultimate strength of some of the wire delivered fell as low as 60,000 pounds and the permissible working stress for this wire was accordingly reduced to 12,000 pounds per square inch. The mean spacing of the circumferential wires was specified to be 1-inch center to center, but the maximum permissible spacing was made 2 inches. Only one set of reinforcing wires was used, located at the center of the concrete shell. Wire of Nos. 6, 8 and 19 gage was used according to the pressure requirements for any section of pipe. The reinforcing cages were made up by winding the wire in shape of an helix on an adjustable drum or mandrel then placing the longitudinal reinforcement by running some wires parallel to the axis of the pipe and some additional ones diagonally and on the outside of the longitudinal wires a second helix was wound in the opposite direction from the first one. As the wire was wound onto the drum under considerable tension, very stiff cages were obtained in this manner. The ends of the wires had to be very securely tied as they would otherwise work loose during spinning operations and cause trouble as actually happened on several occasions. Reinforcement in the pipe was arranged for 30, 40 and 50 feet heads, according to the pressure requirements of any particular section of pipe.

MANUFACTURING OF CONCRETE PIPE

All the pipe was manufactured in the yard on the Tacoma Tide Flats and shipped on flat cars to the site located about 40 miles out of town. Only outside forms are necessary for the manufacture of this kind of pipe. These were made up of steel plate cylinders manufactured in halves bolted together and equal in size to the outside diameter of the pipe. The end rings were made of cast steel held against the ends of the steel cylinders by turnbuckles spaced around the outside of the form. The width of these rings determined the thickness of the concrete shell. Before being placed in use the forms were first oiled on the inside with form oil. The reinforcing cages were then set inside of the forms and the end rings fastened in place. No attempt was made to space the reinforcing steel in the forms because it would invariably take its proper position when the forms started rotating and concrete was fed into them. Concrete was conveyed from a central mixing plant to the forms in steel cars. The forms were placed on a set of rollers driven by a variable speed motor. When starting the rollers concrete was fed into the forms from both ends by shoveling while the speed was being gradually increased.

The proper speed was found to be very important in getting the best results. After some experimenting it was found that the proper peripheral speed for the 51-inch diameter pipe was 3350 feet per minute and for the 63-inch diameter 3250 feet per minute. Close attention was paid to obtaining a dense concrete mix. Mechanical analyses of the aggregate were made, as well as crushing strength and absorption tests. The aim was to produce a mix of the lowest absorption characteristics with the materials available. For instance, it was found that a test of $1:2\frac{1}{2}:1\frac{1}{2}$ mix gave an absorption of 4.4 percent by weight, while a 1:2:2 mix showing the same crushing strength as the former mix within 1 percent indicated an absorption of only 3.5 percent. The mix that uniformly gave the best results was $1:2\frac{1}{4}:1\frac{3}{4}$. The combined fineness modulus for the total aggregate in this mix was 4.4. Slump tests were made very frequently with results already stated.

After sufficient concrete had been fed into the rotating forms to fill them flush with the inside diameter of the end rings, they were spun for a period from 9 to 10 minutes to expel the excess water. The inside of the pipes were then cleaned of laitance and inert materials, and spinning was then resumed for another three or four minutes, during which time the inside of each pipe was trowelled with a steel trowel. The steel trowel was passed back and forth over the inside of a section of pipe until a very satisfactory degree of smoothness was obtained. The trowel used for this work would travel on a light steel guide held in place from supports outside of the rotating form. A long handle attached to this trowel would permit the finishing work to be carried out by a finisher standing at one end of the rotating form. Immediately below the trowel guide there was provided a small trough which would carry off to the outside of the pipe the final surplus water removed by the troweling process.

After the completion of the spinning operation the concrete was hard enough so that the pipe could be moved to the steam room. This was accomplished by an overhead hoist and a small car on rails. In the steam room itself the pipe was moved about by rolling on wooden rails. The temperature in the steam room was kept at about 105 degrees Fahrenheit. The specifications required that the humidity in the steam room was to be such that all surfaces were kept moist. The pipe was kept in the steam room from 10 to 12 hours. From the steam chamber it was then moved to an adjoining shed where the forms were stripped. After removal of the forms the pipe was

moved into an open yard where it was immediately covered with heavy burlap, which would also close the ends to prevent air circulation. It was then sprinkled during the daylight hours for seven days while the burlap was kept on for at least three days. The specifications provided that no pipe was to be shipped before it was 14 days old.

During the air curing process in the yard each section of pipe was provided with a concrete collar 8 inches long, manufactured and reinforced in the same manner as the pipe itself. These collars were attached to the female end of each section with a calked joint about $\frac{3}{4}$-inch thick made with neat cement of very dry consistency. The tenon and recess of the male and female ends, respectively, of each pipe were formed by the cast steel rings acting as end forms. For pipe to be used on curves spacer blocks were used in the forms giving each section the required miter cut. For all manholes, air valves, blow-offs, and service connections, steel castings were set into the steel forms and all reinforcing wires that had to be cut were compensated by placing additional reinforcing around all openings. About one length out of every 12 was given the hydrostatic pressure test at the yard before shipment. The specifications required the pipe to be tested to 125 percent of the safe working pressure for which it was designed. The pipe was to show no appreciable seepage or cracks after a 20-minute test. Several pipes were also tested for external loading by placing the lower $\frac{1}{4}$ of the circumference on a firm support and loading the upper $\frac{1}{4}$ of the circumference with a load equal to the diameter of the pipe in feet multiplied by 1,000 pounds and multiplied by the length in feet of the section tested.

When manufacturing was started it was observed that some of the sections would develop slight hair cracks on the inside while other sections would show hollow spots on the inside as large as one foot square. No doubt on account of insufficient spinning speed thin slabs of concrete from $\frac{1}{4}$ to $\frac{1}{2}$ inch thick would loosen from the concrete in the body of the shell. These spots could always be detected by tapping the pipe with a small hammer. A number of sections had to be condemned on account of not coming up to our test requirements. Some of the conditions that no doubt contributed to our trouble at the beginning were improper grading of the aggregate in our mix, insufficient speed in spinning the forms, lack of sufficient care in handling when moving green pipe from the spinning rack to the steam room, too long an exposure to dry air when moving pipe from the

steam room to the sprinkling yard and improper bedding of pipe sections in the test rack. Which condition contributed most of our trouble, the writer was unable to determine, but by paying very close attention to all of the factors named we rectified our trouble and got satisfactory results. All sections were marked with black paint on the inside while in the yard, giving the date of manufacture, head for which section was reinforced and consecutive number for identification.

LAYING OF PIPE

The pipe was shipped on flat cars to the job and special wooden cradles were placed on the cars so as to avoid contact between adjoining sections. On the job the pipe was distributed along the ditch by a work train and unloaded by a Northwest crane. After unloading, and before laying, the pipe was thoroughly re-inspected and several additional lengths had to be culled out at this time, mainly on account of damage sustained while in transit. Where surface hair cracks were found on the inside of the pipe the contractor was required to wire brush these and paint them with several coats of Valudura paint. Where small hollow sounding spots were located not extending over $\frac{3}{8}$ to $\frac{1}{2}$ inch into the shell, they were chipped out and repaired after the pipe was laid. A number of collars were also damaged in transit and had to be replaced.

The trenching was done by the City with a $1\frac{1}{4}$-cubic yard Northwest hoe shovel and a $\frac{3}{4}$-cubic yard Northwest drag line. The average depth of the trench was 9 feet, with a bottom width of about 8 to 9 feet. Subgrading was done by hand. In many places along this work leaks from the old pipe gave considerable trouble and a couple of sections of the 60-inch diameter line collapsed one night, flooding a considerable portion of the ditch where the laying of the new 63-inch concrete line had just been completed. Fortunately, except for a slight settlement of the concrete line, no harm was done. In several sections of the ditch soft ground was encountered and some apprehension was felt for the safety of the concrete pipe on such a support, but by excavating from 12 to 18 inches below subgrade and backfilling with gravel, a safe foundation was provided and no trouble has since developed in these places on account of after settlement.

The laying operations were handled by a Northwest Crane with 40 foot boom and a crew consisting of six men. After the crew was once organized they would lay from 400 to 500 feet of pipe per 8-hour

day. The weight of a 51-inch diameter section was 6,840 pounds and of a 63-inch diameter section 10,420 pounds. By careful subgrading and laying, good alignment and smooth joints were secured. After the laying gang followed the jointing and cradling gang. Old Manila rope of 1- to 1¼-inch diameter was used as gasket material to protect the open joints of the sections already laid. The cradling crew would immediately follow, tamping the backfill into place up to the spring line of the pipe. Following the cradling crew would come the first pointing of the inside of the joints, which would provide a seal for grouting as indicated on the diagram showing the cross section of a typical joint. The top quarter of the outside of the joints would then be covered with strips of burlap to prevent dirt from entering the joints. A ¾-cubic yard shovel would then backfill the ditch to a depth of about 1 foot over the top of the pipe. All openings in the pipe were kept closed so as to prevent air circulation and to reduce the temperature of the concrete in the pipe to that of the backfill. The tops of the joints were then exposed, the burlap strips removed and the joints were then wetted. After wetting the joints were grouted with a sloppy mix of one part cement to 1½ parts of sand. When the grout had set the joints were again covered with dirt. The backfill was water settled by flooding and final backfill was then completed by the City crews. The final pointing up of the inside joints was finished after the backfilling operations, using a mix of one part of cement to one part of fine sand. A coating of neat cement was brushed over all inside joints 24 hours after completion. The line was now ready for cleaning and final inspection. Brick bulkheads one and one-half brick thick laid in cement mortar were built in the pipe about 50 feet from the open ends. After the bulkheads had sufficiently seasoned the line was filled with water and allowed to remain full for 48 hours in order to thoroughly saturate the concrete. A four-hour field test of the entire line was then made. The line was subject to a test pressure of 150 percent of the operating pressure. Water was metered into the line through a 1-inch meter. For the 51-inch diameter pipe the permissible maximum seepage was 7.08 gallons per minute per mile and for the 63-inch diameter pipe it was 8.71 gallons per minute per mile, or a total of 21.84 gallons per minute for the whole length of both sizes. The total actual loss by seepage was 14.2 gallons per minute, or 65 percent of the maximum allowable under the specifications.

Before the section of concrete pipe could be placed into service it

was necessary to empty the old wooden pipe, dismantle same at three points where it crossed our new concrete line, build in short sections of concrete pipe and connect at each end with the old line. The actual time for building in the three sections of concrete pipe and make connections to the old line required 12 hours. The line was kept dry for an additional 16 hours to allow the points to set sufficiently to prevent washing. The pipe was placed in service October 19, 1928, and with the exception of a few small joint leaks which developed on account of slight after settlement, this concrete pipe appears to be a very satisfactory job in every respect. A few small leaks were repaired without trouble by using lead wool and a recent examination showed the line to be in excellent shape. From preliminary observations that have already been made, we feel that the improvement in the hydraulic conditions of our pipe line on account of the construction of this concrete line are even better than was anticipated originally. It is the intention at some time during this year to make accurate observations of the flow through this pipe and determine at the same time the elevation of the hydraulic grade so that this information may be available for planning future pipe line construction.

Except for the "Hume Process" used in the manufacture of this pipe the work was carried out under the personal direction of the writer. As already stated the pipe was manufactured, delivered, and laid by the Western Concrete Pipe Company of Tacoma with Mr. Chas. Meade as Field Superintendent of Construction. The inspection work in the yard was handled by Messrs. E. M. Stiles and H. S. Baarslag. The field inspection and the Water Division's portion of the construction work was under the immediate direction of Mr. J. A. Kuehl and Mr. B. P. Thomas acted as Assistant Superintendent to the writer on this work. Mr. Ira S. Davisson is Commissioner of the Department of Public Utilities, of which the Water Division is one branch.

MANGANESE DIOXIDE IN THE AQUEDUCT OF THE CATSKILL WATER SUPPLY[1]

By Frank E. Hale[2]

The Catskill aqueduct from Ashokan reservoir to Kensico reservoir was first put into service late in 1915 to serve a portion of the Bronx. Early in 1917 the full available quantity of water from Esopus Creek was brought down to supply portions of all boroughs of New York City. Chlorination at Ashokan headworks was placed in regular operation on January 10, 1925. On December 11, 1924, the flow of water in the aqueduct was increased to approximately maximum capacity, due to the fact that a portion of the Schoharie development became available. In the aqueduct there is visible evidence of the average flow of water at two levels representing about 400 and 600 m.g.d.

A brown deposit formed on the walls of the aqueduct up to the original water level and this deposit exercised considerable influence upon the amount of water flowing through the aqueduct. The deposit reached as much as 1-inch in thickness near Ashokan reservoir, prior to chlorination. As stated above the increased flow in the aqueduct and chlorination were introduced at about the same time. Following chlorination the deposit reduced in thickness, became detached in large areas, and less effect was noted on the available capacity of the aqueduct. The matter seemed of sufficient importance to ascertain the character of the deposit, its distribution, the extent and reason for the influence of the chlorination, with a view to ascertaining whether the introduction of additional chlorination at intervals and at points further down the aqueduct would be feasible and desirable for the purpose of increasing the available capacity of the aqueduct.

Consequently the aqueduct was emptied and inspected on October

[1] Presented before the Water Purification Division, the Toronto Convention, June 26, 1929.

[2] Director of Laboratories, Department of Water Supply, Gas and Electricity, New York, N. Y.

8, 1928, between Ashokan and Kensico reservoirs at numerous points and samples of the deposit were taken for examination in accordance with the data in table 1.

The coating consists of a soft, very dark brown substance (chocolate color), with the exposed surface of a polished or greasy appearance, much like dark wet mud. This can be readily scraped off, being only loosely attached, and patches had been removed by the flowing water and large portions had slipped down near the bottom. Where the entire area in contact with the water was found coated, the surface was uneven, similar to a "spatter-dash" finish obtained with thin mortar. The surface of new coating resembled a "stippled" finish.

The surface of the concrete beneath the coating had a rough sand finish, due to solution of cement at the surface.

TABLE 1

LOCATION	MILES FROM ASHOKAN		DEPOSIT SAMPLE
1	6	Peak Tunnel	1 Old deposit
2	16	Mountain Rest Road	2 Old deposit
3	24	Wallkill Blow-Off	3 Old deposit
4	37	Newburgh Connection	4 Old deposit
4	37	Newburgh Connection	5 New deposit
5	48	Cold Spring Connection	6 Old deposit
6	51	North of Garrison Tunnel	
7	58	Peekskill Connection	7 Old deposit
8	63	Yorktown Heights Connection	

At point 1, coating was in patches covering about one-half the area, maximum thickness $\frac{1}{2}$-inch: no coating along upper wetted areas after water level was raised.

At point 2, condition similar to that at 1, except that maximum thickness of coating was approximately $\frac{1}{4}$-inch.

At point 3, condition similar to that at point 1 and 2, except that coating was about $\frac{1}{8}$-inch.

At point 4, the maximum thickness of the patches was $\frac{1}{4}$-inch, and the areas from which the first coat had dropped off, and also the additional area between the old and new water levels, were covered with a thin new coat.

At points 5, 6, 7 and 8, the entire surface in contact with water was covered with the coating, varying somewhat in thickness; at 5 and 6 the maximum thickness was $\frac{3}{16}$, at 7, $\frac{1}{4}$, and at 8, $\frac{3}{16}$-inch.

The effect of the chlorine had been to reduce the thickness of the deposit, possibly hasten its detachment in areas, and prevent new deposit on fresh cement surface thus uncovered. It was also noticeable that between the old and new water levels no deposit had taken place. This effect of the chlorine reached many miles down the aqueduct since the first new deposit was noted at Newburgh, 37 miles from Ashokan reservoir, and the old coating patches were thicker ($\frac{1}{4}$-inch) than at the point above ($\frac{1}{8}$-inch), 24 miles. At 48 miles and below, across the Hudson, the entire surface was again coated.

The seven samples were examined microscopically both with and without treatment with dilute hydrochloric acid and there was absolutely no indication of any microscopic plant growth or organic structure.

All of the above samples were dried in oven at 105°C. The loss on ignition was then determined on these dried samples, measuring water of hydration. During this ignition there was absolutely no odor of organic matter or any evidence of black char. This would indicate that the deposit was entirely of mineral character. The losses on ignition were as follows:

Sample Number	*Loss on ignition Water of hydration*
	percent
1	16.50
2	18.38
3	17.07
4	18.16
5	12.70
6	16.62
7	17.33

These figures are all very much alike with the exception that the new deposit, No. 5, was somewhat lower than the others.

Qualitative tests of the deposit for the presence of manganese dioxide showed it to be abundantly present. For example, treatment with hydrochloric acid (1:1) produced sufficient chlorine gas to be strongly visible and odorous, and heating produced a strong evolution of green chlorine gas, leaving the residue pale pink.

As there was every indication that the deposits were more or less alike, only samples nos. 1, 4, 5 and 7 were given detailed analysis, nos. 1, 4 and 7 being representative of the nearest point to Ashokan,

an intermediate point, and the furthest point sampled. No. 5 represented the new growth. In taking these samples it was noted that the cement surface had been dissolved by the water, leaving a rough surface of small sand grains. These were obvious also in the samples examined. Under the heading of "Sand and Cement from the walls" has been included the insoluble in hydrochloric acid and the soluble silica, lime and magnesia. The last three were very small in amount, ranging from $1\frac{1}{2}$ to $3\frac{1}{2}$ percent of the total dried weight of deposit. The constituents of the brown deposit have been calculated on a basis of absence of sand and cement from the walls.

TABLE 2

	SAMPLE 1	SAMPLE 4	SAMPLE 5	SAMPLE 7
Sand and cement from the walls, percent	35.64	39.98	56.82	37.01
Brown deposit, percent	64.36	60.02	43.18	62.99

TABLE 3

Analysis of brown deposit

(Calculated on basis of absence of sand and cement. Figures in percent)

	SAMPLE 1	SAMPLE 4	SAMPLE 5	SAMPLE 7
Loss on ignition (H_2O)*	25.64	30.25	29.41	27.52
Manganese dioxide (MnO_2)	46.64	41.51	33.09	41.13
Iron oxide (Fe_2O_3)	20.51	24.07	31.73	19.12
Alumina (Al_2O_3)	7.21	4.17	5.77	12.23
	100.00	100.00	100.00	100.00

* No char nor organic odor.

The chemical analyses of these samples are given in tables 2 and 3.

The amount of sand and cement varies inversely with the thickness of the brown deposit due to variation in amount of scraping of the walls in obtaining samples. The deposit from which no. 5 was taken was very thin and hence contained much more sand.

The largest constituent of this deposit is manganese dioxide. Determination for manganese in the Catskill water as it leaves Ashokan reservoir showed it to be present at this time to the extent of 0.04 p.p.m. It is also present in the Croton supply to the extent of 0.08 p.p.m. which is sufficient to cause deposit of manganese dioxide in

the bottom of Croton Lake, which is disturbed by the fall over-rising to such an extent that visible brown floc of manganese dioxide is present in the Croton aqueduct water in the fall of the year. This manganese dioxide explains the orthotolidin reaction appearing before chlorine is added and which regularly increases every fall dropping to almost nothing in winter. Judging from the phenomena observed with the Croton water the small amount of manganese in the Catskill water is probably the source of the manganese deposit on the wall of the Catskill aqueduct.

In the Journal of the American Water Works Association, volume 18, July, 1927, page 1, was described the work of C. A. H. Von Wolzogen Kühr, on Manganese in Water Works in Holland. It is there stated that the deposit of manganese dioxide takes place through the action of certain bacteria and certain mold growths and a special media is described by which the bacteria were isolated after several months growth. They were obtained from both the water and the brown deposit. This special media was made up at Mt. Prospect Laboratory and streaked with Catskill water and also from the brown muck. In many tests and after many weeks there was no evidence of any bacterial growth *along these streaks* causing a brown deposit of manganese dioxide. Certain molds which undoubtedly fell into the plates from the air during examination caused a brown deposit.

It is our opinion that the manganese dioxide has been deposited from the water by the effect of absorption of alkali from the cement producing an alkaline reaction adjacent to the wall. This alkaline reaction is necessary for the reaction to take place and the inspection and analyses showed that the cement had dissolved from the surface of the concrete. Iron trioxide and alumina may have similarly been deposited from the water or their source may have been the cement.

It was at first thought that the deposit might be due to bacterial action, inasmuch as it was 1-inch thick prior to chlorination in the aqueduct near Ashokan and covered the entire area of wall exposed, whereas at the time of this inspection the deposit at the first point was in patches and only ½-inch thick and no new growth was noted until sampling point no. 4 was reached. Since there is no evidence of bacterial action and hence sterilizing effect of the chlorine, a possible assumption is that prior to chlorination the alkalinity produced by solution of cement from the surface was greater than at present, thereby producing a stronger alkaline reaction. It may be also that, since chlorination, the residual chlorine tends to neutralize

any alkalinity produced in the upper portion of the aqueduct and that this action is lost below Newburgh.

The question of addition of chlorine at Newburgh to reduce the deposit below this point and possibly increase the flow of the aqueduct by 30 m.g.d. is still under consideration.

DISCUSSION

L. H. ENSLOW:[3] Dr. Hale's conclusion that chlorination of the Catskill water at the Ashokan headworks has not only been responsible for eliminating deposition of manganese coatings on the walls of the aqueduct, but, more interestingly, has resulted in dislodgement of existing deposits is supported by the following recorded observations:

From Hanover, Germany, Weber (1) reports that manganese is deposited as hydrous oxides at low pH values not so much by chemical-physical action as by biological influence. Coke filter beds formerly had been absorbing manganese very effectively from previously aerated water. Chlorine applied to the raw water practically eliminated further deposition of manganese in these beds. The same effect was secured to a less marked extent by the chlorine in the filtered water employed in washing the beds by the reverse flow scheme.

At Baltimore (2), to the contrary, the application of chlorine to the water going to one of a battery of filters increased the manganese removal. In this instance, however, the manganese precipitation was effected by coagulation with ferrous sulphate. Lime sufficient to secure alkalinity in excess of pH 8.8 was applied to secure coagulation and, therefore, the chlorine probably increased the efficiency of the process, i.e., improved production of manganic and ferric hydroxide floc.

The observations of Dr. Hale and his associates that chlorination stopped deposition of manganese and loosened the old deposits for a distance of 37 miles below the point of chlorination, but that new deposits were observed beyond the 37 mile point, strongly indicates the correctness of the claims of Kühr (3), Weber (1), Tillmans (4) and others that removal of bivalent manganese from water is at least in part a biological process.

The facts indicate that within the zone of chlorine influence the depositions have ceased whereas below this zone the deposition now

[3] Research Engineer, The Chlorine Institute, New York, N. Y.

proceeds with little or no suppression. Such observations strongly indicate that the deposits were due to biological phenomena primarily and secondarily to the power of adsorption and chemical oxidation of manganous ions by the "activated" manganic hydrous-oxides already formed. It is entirely probable that the first film of manganic hydroxide on the concrete surface was of chemical origin, because of the highly alkaline reaction always found at the surface of new concrete and which was essential to the rapid oxidation of the manganese. The protective coating supplied by the first film deposited would seemingly not allow for a continuous effect of the soluble alkali from the concrete in the building up of a film on which active deposition was proceeding at a surface ½- to 1-inch from the concrete surface. It is probable, however, that this chemically deposited initial film of manganic hydrate was vital to the continued deposition regardless of the nature of the process.

Tillmans (4) and his coworkers point out that bivalent manganese absorbed on the tremendous surface area presented by manganic hydroxide is oxidized slowly by the oxygen in the water, the action being purely chemical. In practice, however, he finds that the action is greatly accelerated by the presence of microörganisms.

Additional experience in the application of chlorine to manganese problems is found in the recently reported practice at the Beverly Hills, California (5), water softening and sulphur removal plant. Filling the filter beds with heavily chlorinated water (2.5 p.p.m. or more free chlorine) followed by contact of 24 hours and then thorough back washing causes the so-called "mud-balls" produced by manganese deposition to disintegrate. By such practice the sand beds are maintained in good condition and without damage to the underdrainage laterals, etc. This effect would indicate that the root of the trouble was biological in nature and that super-chlorination destroys the growths which are associated with manganese depositions. The result seems markedly parallel to the disintegration of the already deposited coatings in the Catskill Aqueduct following the introduction of continuous chlorination.

That problems of manganese depositions may be solved by chlorination may prove to have considerable economic significance in increasing the capacity of aqueducts, mains, etc., and for conditioning filter beds.

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WELLS AS A SOURCE OF MUNICIPAL WATER SUPPLY[1]

By Wynkoop Kiersted, Jr.[2]

Much of the area included in the Rocky Mountain Section of the Association is high, comparatively level plains country that is not freely supplied with surface water. Some of this semi-arid land is underlaid with water bearing deposits to which municipalities naturally turn in search of a water supply. The extremely mountainous portion, on the other hand, is the fountain head of mountain streams. Between the two divisions just mentioned there is a middle ground embracing the foot hills of the mountains. Cities located here in many instances have laid long pipe lines into the mountains to obtain unpolluted soft water. This procedure has proved economical in the past since a satisfactory gravity supply could thus be obtained without the heavy operating expenses attending artificial purification and pumping of water.

These streams, although once clean and satisfactory for domestic supplies, are rapidly becoming contaminated. It is now found necessary in many instances to add purification costs to already high fixed charges incident to the construction expense of long pipe lines. Chlorination alone, without the continuous supervision of a skilled technician, cannot be safely relied upon to safeguard a city against the effects of increasing stream pollution. Filtration requires a skilled attendant, but does not depend upon the delicate adjustment of a machine to perform effectively its duty and when employed for purification adds an additional line of defense behind which chlorination can be accomplished with greater security. Doubtless many cities of the foot hills will find it economical to construct purification works and to continue to use mountain streams as a source of supply, but others will find the economic balance reversed in favor of well water supplies.

Here again the problem of purification may be encountered when the well water is very hard. The wholesomeness of deepseated well

[1] Presented before the Rocky Mountain Section meeting, February 15, 1929.

[2] With Wynkoop Kiersted, Consulting Engineer, Kansas City, Mo.

water in its natural state is usually accepted without question, but it may become contaminated through careless construction. For instance, where wells have been improperly constructed surface pollution may leak down along the well casing. Sink holes or crevices in rock formations may also allow contaminated surface water to find access to the water bearing stratum from which the well water is pumped, particularly where such strata are near the surface of the ground.

We find it necessary, therefore, to keep careful watch at all times over the sanitary quality of every public water supply, even those untreated supplies which are presumably safe on account of remoteness or inaccessibility. Instances can be cited where epidemics attended with many fatalities have followed a gross pollution of a water supply from unsuspected causes. It follows, therefore, that a city must make the water supply intake safe against any danger of pollution or supply itself with ample means of purification if it expects to escape liability from the devastating results of water born diseases. The percentage of sporadic outbreaks is naturally much smaller with water supplied from wells than it is from even supposedly safe surface sources.

A few statistics compiled by W. S. Johnson, State Sanitary Engineer for the State of Missouri, may be of interest in this connection, because they may be representative of conditions in other states.

Mr. Johnson reports that there are 201 sources of public water supplies in the State of Missouri. In a number of cases two or more cities are furnished water from a single source and in all there are 217 municipalities supplied. Of these 201 sources, however, 121 are wells, 10 are springs and 70 are surface sources. Fifty-eight and seven-tenths (58.7) percent of the wells, 20 percent of the springs and 52.9 percent of the surface supplies have been "Approved" by the state sanitary engineers. The water must be bacteriologically safe and the supply works must be satisfactory as to construction, equipment and operating methods in order to receive the approval of the State Board of Health. Thirty-nine and six-tenths (39.6) percent of the wells, 40 percent of the springs and 31.4 percent of the surface supplies have been "Conditionally Approved." That is, the water has been found safe by the bacteriological tests of the State Board, but the structures, equipment or operating methods have sanitary deficiencies which open the door to the possibility or in some cases even to the probability of contaminated water reaching the consumers undetected.

In most cases the State Board of Health allows a specific interval of time after their survey in which a city may remedy the defects. In case a remedy is not applied in the prescribed time the source of supply will automatically become "Disapproved." A survey just completed discloses the fact that 1.7 percent of the wells, 40 percent of the springs and 15.7 percent of the surface supplies have been "Disapproved;" the water having been found unsafe bacterially because of defective structures, equipment or methods. The statistics accordingly show that only 2 wells were found to be actually polluted, although a good many lacked such precautionary devices as seals around the well tops. Water from a considerable number of surface sources, on the other hand, was either actually contaminated or open to suspicion.

The importance of wells as a source of municipal supply has long been keenly appreciated by engineers and the public in general. We find that 41 percent of the municipal supplies of Colorado are obtained from wells in spite of the fact that a large portion of the State is abundantly supplied with surface water. In the states of New Mexico, Arizona, Texas, Okalahoma, Arkansas, Kansas and Missouri the percentage of well supplies ranges from 65 to 78 percent of the total number of public supplies in use. Many cities throughout the country located upon the banks of rivers, frequently find it desirable to take their water supply from the ground. Memphis, Tennessee, is a noteworthy example of this practice. In Texas we find such large cities as Houston, San Antonio, El Paso, Galveston and Amarillo depending entirely upon wells. Lincoln, Nebraska, Des Moines, Iowa, Albuquerque, N. M., and a long list of others of equal importance supply their respective inhabitants with well water.

PRELIMINARY INVESTIGATIONS ESSENTIAL

The probable yield of any ground water development can be ascertained in advance with reasonable accuracy by a careful study and investigation of existing conditions. On the other hand, failure of such undertakings can nearly always be traced to a disregard of controlling physical and climatic conditions such as the rainfall, the tributary catchment area, geological formations, depth to and extent of the water bearing deposits and the general slope of the ground water table. Geological reports afford much valuable information which, when coupled with a knowledge of conditions gained from existing wells and from borings and test wells put down as directed by the investigator, lead to reliable conclusions. Much

delay is frequently caused the water supply engineer in reporting upon ground water supply extensions because of the absence of records relating to existing wells. Such records should show the initial yielding capacity of each well at different amounts of drawdown, the effect that wells, individually or collectively, have had upon the ground water level, the extent to which the strainer may have become clogged, the amount of sand removed by pumping or in cleaning the wells, seasonal variation of water level and similar data. No one properly impressed with a realization of the importance of such information would object to recording it systematically. The absence of these records can be attributed, therefore, only to a lack of sound business methods on the part of those responsible for their keeping.

It is far more economical in the long run to spend money freely for geological studies, borings, test wells, etc., necessary to a comprehensive engineering report than to expend a much larger amount of money illadvisedly in any well water supply project. The study commences when the investigator first arrives upon the ground and cannot be regarded as completed when the wells have been constructed, but should be continued until they have served their useful life. A careful examination of geological structures and general reports and a mapping of the terrain lays the ground work for an extensive investigation. To insure maximum economy in the matter of borings and test holes one must proceed cautiously in order to select controlling locations for tests. It is from such data that the design of the well and drilling methods to be employed must be determined. When these matters have been satisfactorily settled and the first well drilled the investigator's attention is next absorbed in the development and test of the well. This is generally accomplished by a high capacity, variable speed pump furnished by the contractor. The effect of pumping at different rates upon the ground water level should be carefully recorded and the rapidity with which the water level returns to or near the original elevation when pumping ceases. When time permits a long time pumping test provides a close estimate of the yielding capacity of the well and maximum operating economy can thus be determined and a pump purchased for final installation that will most nearly suit conditions of capacity and head. The highest pump efficiency and lowest operating cost can only be obtained when the pump is designed for conditions of capacity and head under which it will actually operate. It will

generally be found more economical to pump from wells at a moderate rate than to tax them to the limit in an endeavor to obtain a definite quantity of water, even though a lower pumping rate entails the construction of additional wells. More wells have been ruined and more money wasted for power in trying to make one well do the work of two than from other cause.

SPACING OF WELLS

When the economical capacity of the first well has finally been determined the next step is to choose a site for the second and succeeding wells. Here again physical conditions such as direction, velocity and slope of underground flow and the extent of the water bearing formation are controlling factors. The work of drilling and testing should proceed slowly and with careful attention, since it will be found that no two wells can be developed in exactly the same manner and with equally satisfactory results. The effect, if any, that successive wells have upon others of the group and upon the general ground water table is, of course, highly significant. With such continuous care a properly balanced system can be developed that will draw from the ground the largest quantity of water economically feasible.

With the completion of the wells the services of the engineer, contractor and others employed to design and construct the wells are discontinued. It then automatically devolves upon the water superintendent to continue the study of the operation of the wells and their effect upon the ground water level. The importance of this continued and systematic observation and record of conditions cannot be over emphasized. These historical facts are particularly essential in presenting convincing evidence when extensions become necessary and in planning for new wells.

IMPORTANCE OF CONTINUOUS RECORDS

Mr. R. B. Edinburg, Superintendent of the Amarillo, Texas, water supply works is keeping an unusually fine and complete set of records which show almost at a glance the comparative operating economy of the respective wells and all pertinent data relating to ground water level. This project, originally designed in this office, was put in operation in August, 1927. A description of the development was presented before the Chicago convention in 1927 and appeared in **The Journal** for July, 1928. It was there pointed out that 500 to 800

g.p.m. were expected from each well, a thing made possible only through the employment of methods of development suited to a well in sand of extreme fineness. The methods used are described in the article referred to.

AMARILLO, TEXAS, OPERATING RESULTS

The wells were sunk by the double casing method, a permanent 12-inch casing being installed concentrically in a temporary 20-inch oil well casing. The 20-inch casing was slowly withdrawn as gravel was fed down through the annular space between the two casings. During the gravelling process the wells were alternately pumped by air lift and back blown in order to remove as much sand as possible. To back blow a well the discharge valve was closed thus cutting off the escape of air and forcing water and air out through the perforated strainer section of 12-inch casing and back into the ground. A sudden opening of the discharge valve allowed the mixture of air and water to rush back through gravel which had already been deposited around the strainer carrying much sand with it into the well. The process of pumping, back blowing, feeding gravel and withdrawing the 20-inch casing was continued in each case for nearly a month or until at least 100 cubic yards of screened gravel had been deposited around the strainer. By that time the gravel had been worked back six feet or more from the 12-inch casing and the velocity of water entering the gravel area had become so low as to carry only a small amount of sand with it which could not be appreciably reduced by further development. A well was then considered to be ready for the installation of a pump. The showing of the first well that a continual run of sand in small quantities might be expected for an extended period of time induced the decision to pump the water by air lift and also to provide for graveling the wells periodically to replace the sand removed. The remaining wells were accordingly drilled deeper than the first so as to provide economical submergence of the air pumps.

Well No. 1 was equipped with a mechanical pump because, being the first well, it had not been drilled deep enough for economical submergence of an air pump. A mechanical pump was also placed in Well No. 2 because of an impending scarcity of water in Amarillo which the operation of the two pumps could avoid while the permanent air lift equipment and pipe lines were being installed. The mechanical pumps were designed with large clearances to accommodate a small amount of sand in the water. Maintenance expense of

these pumps has been high, however, and it is likely that the pump in No. 2 Well will be replaced by air lift.

The wells have now been pumped for nearly a year and a half and a word or two as to the operating results would probably be of greater interest at this time than details of design which have already been rather completely described in the paper referred to above. Mr. Edinburg's carefully kept records show that during the first ten months of 1928, 459 million gallons of water were pumped by air lift against a head of 76 feet and that 142 million gallons were pumped by the motor operated turbine pumps against a head of 74 feet. The electric power metered to the motor operated air compressors amounted to 900 kw. hrs. per million gallons pumped, whereas, that metered to the mechanical pumps amounted to 905 kw. hrs. per million gallons. Maintenance of all air lift equipment including air compressors, air lines, and the pump installations at the wells amounted to $0.51 per million gallons, whereas the cost of maintenance upon the mechanical pumps was $4.23 per million gallons. The high maintenance expense of the mechanical pumps and their unusually low operating efficiency was occasioned by sand abrasion.

Gravel has been added to each of the wells at an average rate of 4 or 5 cubic yards per month. The static water level has risen slightly due, in all probability, to the proximity of a partially filled storage reservoir. The yield of the wells in g.p.m. per foot of draw down has increased somewhat, which is contrary to the usual experience with wells located in fine sand strata. The increased yield clearly indicates the effect that the occasional back blowing of the wells has had in reducing frictional losses through the ground near the well. Pumping rates have run as predicted from 500 to 800 g.p.m., the latter rate having been maintained for several weeks at a time from one of the air lift wells.

The suitability of air lift pumping to the Amarillo project has been unquestionably demonstrated by the results of the first year's operation. It cannot be said, however, that air lift suits all conditions of pumping equally well. There are in fact conditions of service to which each type of well pump is adapted better than any other and for that reason a brief summary of the relative advantages of the different types is given herewith.

COMPARISON OF MODES OF PUMPING WELLS

Horizontal centrifugal pumps can generally be most economically employed for pumping wells where the ground water level is near the

surface. These pumps are low in first cost, simple and reliable to operate, light in weight, easily maintained, are high in efficiency but cannot be installed where the suction lift exceeds about 20 feet, although the pump itself may be located in a pit to allow it to pump water that is deeper than 20 feet below the ground level. The vertical centrifugal pump can be installed where the depth to water is 200 feet or more but it has not been widely used where the depth exceeded 60 or 75 feet. Vertical centrifugal pumps require the use of a rather extensive system of structural steel supports to prevent shaft vibration, and for this reason they have been almost entirely superseded for well pumping by the turbine type of pump.

Turbine pump design has been rapidly improved in recent years until now this type of pump has come into more general use, meeting satisfactorily a wider range of conditions than any other pump. A few years ago a turbine pump installation 200 feet in the ground was considered a deep one but today 300-foot installations are frequent and occasionally installations are made over 400 feet deep. These pumps are suspended from a thrust bearing at the surface of the ground which carries not only the pump and shaft but also the weight of the column of water being pumped. Where water is to be delivered into a standpipe or distribution system some manufacturers have designed a vertical type booster pump located just beneath the motor base in order to relieve the well pump of as much pumping load as possible. Turbine pump operation is attended with little hazard, small maintenance expense and few operating difficulties when hanging plumb and pumping water free of sand. It has greater capacity than any other mechanical pump that can be installed in a well of a given size.

The deep well plunger pump is best adapted for pumping sand free water in amounts up to about 50, or in some cases up to 100 g.p.m. There is a demand for plunger pumps of higher capacity where the water level in the well is too far below the surface of the ground for economical turbine pump operation. Rod breakage, the source of greatest annoyance, develops quickly when a pump is operated above the yielding capacity of the well or so that it takes air. For this reason one must be particularly careful to avoid the installation of too large a pump. When due regard is given to the limitations of the plunger pump, however, it can be operated at high efficiency and when well designed with moderate operating expense.

The air lift pump is particularly adapted to pumping sandy water

that would wear moving parts excessively, to installations in crooked wells, when high overloads are occasionally desired, when the action of the air aids in the removal of dissolved gases and iron, and to pumping wells where the maintenance of mechanical pumps would be unusually high. Air lift pumping on the other hand becomes less applicable where high unit-power cost prevails, for pumping single well installations and where sufficient depth of wells cannot be obtained for economical submergence of the air pumps. Air pumps installed 300 feet or so deep should be submerged below the pumping level of water in the well a distance equal to about 40 percent of the distance from the pump to the limit of the lift. The pump submergence in the case of shallow installations of about 40 feet should be near 75 percent. The economical submergence for other lifts will usually be found to fall between the limits of 40 and 75 percent. When sufficient depth for proper submergence is available there is no limit to the height to which water may be raised by air lift. As a usual thing it will not be found economical to provide the necessary submergence for very high lifts.

The overall efficiency attainable under ideal conditions by the centrifugal, turbine or plunger type pump is high, ranging in most cases between 60 and 70 percent based upon the ratio of electrical current consumed to water pumped. Its day in and day out operating efficiency may be found to be much lower, however, depending to a large extent upon the readiness with which repairs may be accomplished and the extent to which repairs are warranted by the expense of power. A high unit power rate invariably acts as a stimulus to efficient operation. Horizontal centrifugal pumps located above the ground will be found operating at somewhat higher efficiencies than the turbine or plunger pumps on account of the ease and economy with which repairs can be made to them.

At present the highest attainable efficiency of the air pump is about 50 percent and the highest overall efficiency including the efficiency of the motors, air compressor, pipe lines and the air pump itself is about 35 percent. The centralized operating machinery of an air lift installation can be readily lubricated, can be protected from abrasive dust and is usually housed in a well lighted building where defects can be quickly noticed and easily repaired. The daily operating efficiency, therefore, generally bears a closer relation to test efficiency under ideal conditions than do the respective efficiencies of mechanical pumps. The field for the use of air lift is not broad. Its

advantages should be recognized, however, in order to utilize that method of pumping under and only under conditions to which it is adapted.

Electric power will generally be found most convenient and economical for operation of the pumps or air compressors. A low power rate can usually be obtained on account of the highly desirable characteristics of a municipal water pumping load for which the largest power demand occurs during the summer months when the power line is carrying its lightest load. A very low electric rate can at times be had by agreeing to take all power for water pumping at the electric company's off-peak hours. Wells may be located out of reach of an existing power line or it may be impossible to obtain an advantageous rate. Under such conditions steam, oil or gas engines may be employed. Steam engines can nearly always be used most economically where there is use for the exhaust steam for heating or industrial process work but municipal plants seldom have use or a market for exhaust steam. The choice between oil and gas will depend almost altogether upon the availability and price of the two fuels since either can be used with success in internal combustion engines. A comparative analysis of the cost of pumping water using electric, steam, oil and gas engine power should always be made before becoming finally committed to any one of these sources of power in order to insure maximum operating economy.

WELLS, IRON REMOVAL PLANT AND DIESEL PUMPING EQUIPMENT AT SIOUX FALLS, S. D.[1]

By F. G. Gordon[2]

The Sioux Falls water supply is obtained from shallow wells located in the broad river valley of the Big Sioux River, north of the city. From these wells it is pumped to an iron removal plant, and from the reservoir under the iron removal plant by a second pumping into the distribution system. The pumping equipment at the wells is all motor-driven, while the high service pumps are driven by Diesel engines, with a motor-driven centrifugal pump and a steam pump used for standby service. There are three elevated tanks and one standpipe located on the distribution system.

The sand and gravel stratum from which the water comes apparently covers a very wide area throughout the river bottom. This stratum lies under a top soil approximately 10 feet deep, and over a dense clay blanket found at a depth of 35 to 40 feet below the surface.

UNUSUAL DESIGN OF WELLS

The present supply comes from two large circular, open wells, each 50 feet in diameter, and from five closed wells of a type invented and patented by Mr. Maury, the writer's partner up until the time of his retirement from the firm of Maury and Gordon.

The design of these wells was made with the idea of securing certain results which could not be obtained with any other type of well in use. It was desired to have a well in which horizontal motor-driven centrifugal pumps could be placed, which would prevent contamination in any way, and which would have an enormous strainer area. All of these things have been accomplished in the type of well used. Since it would be very difficult to give an adequate word picture of the design of this well, a model has been built to show

[1] Presented before the Missouri Valley Section meeting, November 7, 1929.

[2] Of Gordon and Bulot, Consulting Engineers, Chicago, Ill.

its construction, the model being on a scale one-twentieth of that of one of the wells now in service. It is shown in figure 1.

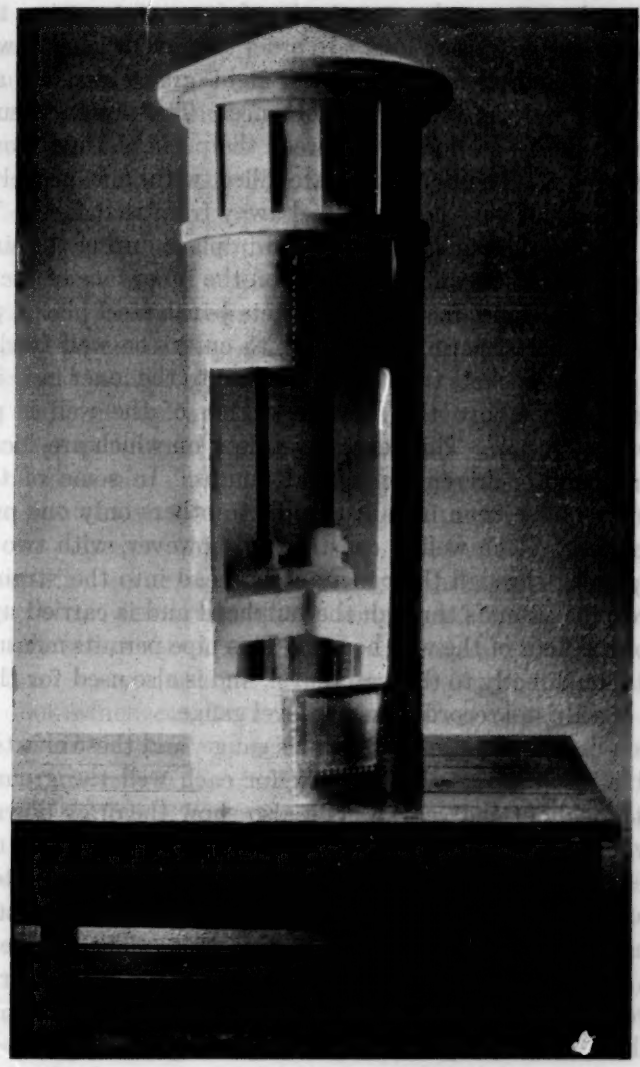

FIG. 1. MODEL OF WELL USED AT SIOUX FALLS

The model consists of a cylindrical shaft, surmounted by a well house. The lower portion of this shaft has a strainer area extending completely around the circumference, which permits the water to

enter the well. The diameter of each well is 18 feet. In each well there are 4216, 2-inch holes, having a total area of 92 square feet. Since these holes are distributed around a circumference of 56 feet 6 inches, there is ample opportunity for water to enter the well without excessive friction loss. In order to prevent sand flowing into the well through these large holes, eight gravel pockets are constructed around the inner circumference. The design is such that concrete columns are located between the pockets, thus providing a rigid cylinder. These pockets are filled with fine gravel on the outside face and very coarse gravel away from that face. The fine gravel next to the outside face is held in place during the sinking of the well by a screen which is placed on the inner face of the outside plate. On the inner face of the pockets ½-inch steel plates, punched with 1-inch holes, permit the water to enter the well freely. The width of these pockets from the outer face to the inner face is 2 feet.

Immediately above the strainer section of the well is placed a concrete bulkhead. This serves as a floor on which are located the horizontal motor-driven centrifugal pumps. In some of the wells two pumps have been installed, while in others only one pump has been placed. Each well is constructed, however, with two suction pipes passing through the concrete bulkhead into the strainer area. A third pipe extends through the bulkhead and is carried up to the level of the floor of the well house. This pipe permits measurements to be taken directly to the water level, and is also used for the installation of a Bristol recording water level gauge.

Seven-day charts are used on this gauge, and these charts provide valuable information. They show for each well the ground water level throughout the year. They also show the draw down of each well when pumping, and the hours that each well pump is operated.

The manner of constructing one of these wells is quite simple. The top soil at the location of the well is removed and the steel work for the strainer section erected in this hole. The concrete which forms the cutting edge, and the concrete for the triangular columns located between each of the gravel pockets, is next poured. A clamshell or orange peel bucket is then used to excavate from the interior of the well, and as material is excavated, the well sinks. Sixteen gauge steel plates, bolted together with stove bolts, serve as the outside form for the circular well wall. When enough material has been excavated from the interior of the well so that the well has sunk a distance of four or five feet, a section of wall of that

height is poured, the inner forms removed, and the excavation and sinking continued for another four or five feet, when the operation of pouring another ring of concrete is repeated. This process continues until the cutting edge at the bottom of the well reaches the top of the clay, some thirty-five or forty feet below the surface. Water is encountered some ten or twelve feet below the surface and the sand and gravel below this point is, of course, removed in the wet.

The well having been sunk to the clay, the next step is the placing of the concrete bulkhead. The wall of the well is so formed that a shelf or ledge exists at the top of the strainer section. A circular form of the cross-section of the interior of the well is assembled on the ground adjacent to the well. Holes are placed in this form at the proper location for the two suction pipes, and the test pipe. The form is then placed immediately over the top of the well and the two suction pipes and the test pipe are inserted through the holes previously made in the form and are bolted to the form so that they are held rigidly in a perpendicular position.

Each of these pipes has a valve at its upper end, which is in the proper position to be about twelve inches off the bulkhead floor when it has been poured. These valves are closed and are covered with burlap or other material and the form, with the suction pipes and valves, is then lowered through the water until it rests on the ledge immediately above the strainer section. Concrete is now deposited on this form by means of closed buckets. These buckets have a bottom door which can be unlatched to allow the concrete to be emptied when the buckets reach the top of the form. By this method the concrete for the bulkhead is deposited under water up to an elevation six inches lower than the finished bulkhead floor level. During this process the water on the inside and the water on the outside of the well are at the same elevation.

The next step in the process is to place a layer of grout on top of the already deposited concrete. While this is being done, the water level on the interior of the well is carried at an elevation higher than the ground water level outside of the well. This difference in hydrostatic head forces the grout into the concrete and insures a water-tight floor. In the five wells of this type which have been constructed for Sioux Falls, no trouble has been experienced in any of these wells in making the floor water-tight.

After the concrete and grout have set up, the water on the inside of the well is pumped out, thus leaving a dry pump pit. The pumps,

together with their discharge piping, are then installed, the valves on the suctions are opened, and the pumping equipment is ready for operation. Since the static ground water level is higher at all times than the elevation of the top of the pump casings, these pumps are primed at all times. All of the well pumps are operated from the main pumping station.

HORIZONTAL CENTRIFUGAL PUMPS USED

Rather interesting installations have been made in wells 3 and 4. These are the two large circular wells previously described. When first installed each was equipped with a vertical motor-driven deep well pump. The lack of high efficiency of the vertical pumps and the need for an emergency unit for each well suggested the possibility of placing in each well a horizontal motor-driven centrifugal pump on a raft. Rafts were constructed, each consisting of a wooden platform mounted on steel oil barrels. An I-beam was bolted vertically to the interior wall of the well and a yoke, with rollers, was fastened to the raft in such a manner that with a raising or lowering of the water level in the well the rollers move up and down on the inner faces of the outstanding flange of this I-beam. Flexible hose connections are installed from the discharge of the pump to the pipe leading from the well to the iron removal plant. These installations have been in service for twelve years and have required very little attention, outside of an occasional renewal of the hose.

DETAILS OF IRON REMOVAL PLANT

Strict economy dictated the use of several of the more unusual features in the 8-m.g.d. iron removal plant, built at a cost of $11,125 per million gallon capacity. Small filter units permitted hand operation of the valves. Recording water level gauges on the filter effluent line replace the ordinary integrating loss of head gauges. A spent wash water storage sump spreads out the discharge so that a smaller drain answers. The underdrains consist of a steel plate false bottom into which nozzles are screwed.

Before preparing final plans, an experimental plant was operated to determine whether aeration, followed by sedimentation and filtration, but without the use of chemicals, would remove the iron satisfactorily. As the results with the experimental plant indicated a 96 percent removal, it was decided to employ this process in the contemplated plant.

The aerator is of the weir-step type, in which the water cascades down concrete steps on which removable 1½-inch pipe are placed to break up the stream. From the aerator the water flows into one end of the sedimentation basin and is collected at the other end by an overflow weir, from which point it passes to the filters.

There are 16 filter units, each having a capacity of 500,000 gallons per day when operating at a rate of 125 m.g.d. per acre. The use of units of this size was influenced by operating conditions and by structural reasons. It was expected that, from the standpoint of hand operation which had been decided upon, it would be easier to operate the valves for the plant as designed than to operate the fewer but larger valves of a plant having larger units.

Each filter unit had when placed in operation 30 inches of sand and 15 inches of gravel, the gravel resting on a ½-inch steel plate which is supported by short cast-iron columns. The gravel was screened to size and deposited in the filter in the following layers:

Thickness of layer	Size of gravel
5 inch	2 inch to 1 inch
3 inch	1 inch to $\frac{5}{8}$ inch
3 inch	$\frac{5}{8}$ inch to $\frac{3}{8}$ inch
2 inch	$\frac{3}{8}$ inch to $\frac{5}{16}$ inch
2 inch	$\frac{5}{16}$ inch to size passing No. 10 sieve

Specifications called for a sand having an effective size of from 0.35 to 0.50 m.m., and as low a uniformity coefficient as possible. The steel plate which serves as a false filter bottom is drilled and tapped on 6-inch centers to receive ⅜-inch brass nipples, to which cast-iron umbrella-shaped nozzles are screwed. The area of the openings through the brass nipples is 0.53 percent of the total area of the filter bed. The area of the openings through the nozzles is in excess of the area of nipple openings. The distribution of wash water is apparently very uniform.

A new type of rate controller manufactured by the International Filter Company was used in this installation. This controller is of the Venturi type, with a butterfly valve operated by a diaphragm. Tests, in which the head on the inlet side was varied from 2.5 to 5 pounds in an interval of one minute, showed a variation in discharge of less than 5 percent.

Recording water level gauges were used for loss of head gauges. The gauges for adjoining filters were mounted back to back on 1-inch gauge boards located on the operating floor. Although this type of

gauge is not differential in its action, it gives a satisfactory record because the water level in the filters is carried within a few inches of the same elevation at all times.

Since a single wash water pump is provided, for emergency use a connection is made to one of the high service mains leading from the pumping station to the distribution system. The friction loss through this connection was carefully calculated, and the size of the pipe selected so that the wash water pressure when delivering a sufficient quantity for washing purposes would not be excessive.

A sump having a capacity of 40,000 gallons was constructed to receive the wash water from the filters. The construction of this sump permitted the use of a 10-inch cast-iron drain from the sump to the nearest city sewer instead of the 16-inch drain which would have been required if the sump had not been built. The saving due to the use of the smaller drain amounted to $5,887, while the cost of the sump was only $1,617. Cast-iron construction for the drain was necessary because of its proximity to the gravel stratum from which the water supply is obtained.

The office, laboratory and pump room are located at the front of the filter plant building. The pumping equipment, which is all motor-driven, consists of a wash water pump, three auxiliary low-lift pumps, which can be used as boosters to assist the well pumps during the periods of low ground water, and one high-service pump.

The concrete used in the filter tanks and in the walls of the sedimentation basin consisted of one part of cement to five parts of coarse and fine aggregate. The slump test was used to control the amount of water in the concrete. Concrete was mixed for one and a half minutes after all ingredients had entered the mixer and was placed with two-wheel carts. As the concrete for the walls of the sedimentation basin was deposited during the winter, the materials and water were heated and the concrete placed in forms which were protected by heavy straw mats on the weather side. Salamanders were used on the interior.

Beneath the iron removal plant is located a clear water reservoir, built several years prior to the construction of the iron removal plant. This reservoir is 116 feet square and has a capacity of 1,200,000 gallons. The construction is of interest in that the floor of the reservoir is composed of a series of inverted groined arches. At the time this reservoir was built the ground water level was some four or five feet higher than the bottom of the reservoir and the design

was influenced by this fact. The city guaranteed to keep this ground water level down during the construction of the reservoir and was thus able to secure much lower bids than would have been the case had contractors bidding on the work given consideration to this contingency.

The city had four 10-inch wells sunk, one at each corner of the reservoir and connected these wells to a suction pipe leading to one of its high service pumps. By operating this pump during the period of construction, no difficulty was experienced in keeping the ground water level safely below the bottom of the excavation for the reservoir.

After the reservoir had been completed, the four wells were capped with check valves opening in to the reservoir, thus permitting water to flow into the structure whenever the water level on the interior was lower than the ground water level on the outside.

DIESEL ENGINE DRIVES

In 1915 the city decided to install Diesel engine-driven pumping equipment for regular service, and to relegate its steam-driven pumps to standby or emergency service. Two Busch-Sulzer engines, each of 160 h.p., were selected to drive Aldrich triplex pumps, each having a capacity of 1600 gallons per minute against 190 foot head. On each engine shaft was mounted a generator of 135 kva capacity. A friction clutch installed between the generator and pump permitted the pump to be cut off from the engine and the generator operated as required. These Diesel engine-driven triplex pumps have been in service continuously since their installation and have been entirely satisfactory. In 1926 the city added to its Diesel engine equipment by installing a 400 h.p. McIntosh & Seymour engine, with a 270 kw. generator mounted on the engine shaft and driving a horizontal Worthington pump through a friction clutch. All of the Diesel engines are of the four-cycle air injection type. Fuel oil is supplied from small tanks overhead which are in turn filled from large steel storage tanks located at the south end of the station building. Cooling water is from the city mains.

THE RELATION OF DIRECT BACT. COLI AND BACT. AEROGENES COUNTS TO SOURCES OF POLLUTION[1]

By Fred O. Tonney[2] and Ralph E. Noble[2]

Recently developed direct plating methods of counting coli-aerogenes organisms, by enumerating the distinctive colonies on a differential medium, have made possible the routine determination of separate Bact. coli and Bact. aerogenes indices in 48 hours by the same process in which the group index is obtained.

Our experience with such a method, employing cyanide-citrate agar as the differential medium (1) (2), led us to consider the possibility that additional data of primary sanitary significance bearing directly on fecal pollution might be available for practical use, in the individual Bact. coli and individual Bact. aerogenes counts thus obtained, and also in their numerical relation to each other. Possibly separate Bact. coli and Bact. aerogenes indices, if quickly obtainable in routine water analysis, might offer a better basis for discriminating sanitary judgment of true fecal pollution than does the combined coli-aerogenes index, which includes a variable number of organisms not exclusively of fecal origin.

Accordingly a comprehensive study was undertaken of the types of material in which the coli-aerogenes group commonly occurs, to determine the value of the direct plating method as a specific fecal test; that is, to ascertain whether it would yield a characteristic picture in known fecal samples, which might be useful as evidence of fecal pollution when encountered in samples of unknown origin. We also desired to know whether the colony characteristics on the differential medium would afford a serviceable means of distinguishing Bact. coli from Bact. aerogenes, and would give findings reasonably consistent with recognized differential tests.

The phase of the investigation here reported was directed toward

[1] Presented before the Water Purification Division, the Toronto Convention, June 27, 1929.

[2] Bureau of Laboratories and Research, Department of Health, Chicago, Ill.

the primary sources from which these organisms find their way into water supplies. It consisted of a study of the direct counts of "probable Bact. coli" and "probable Bact. aerogenes" colonies,[3] obtained with cyanide-citrate agar, in (1) human and animal feces as the primary source of Bact. coli; (2) soils, grains and decayed wood as principal sources of Bact. aerogenes, and (3) sewage and surface water as composite mixtures derived from the two general sources named.

TABLE 1

*Relationship of Bact. coli and Bact. aerogenes colonies from fecal and non-fecal sources**

SOURCE	SAMPLES	COMBINED COLI-AEROGENES (AVERAGE PER GRAM IN AGGREGATE)	PERCENTAGE		RATIO OF COLI TO AEROGENES
			Coli	Aerogenes	
Feces:					
Human	132	92,800,000	99.63	0.37	270: 1.0
Animal	324	689,000,000	99.42	0.58	171: 1.0
Human and Animal	456	517,000,000	99.23	0.77	129: 1.0
Cereals	60	397	5.9	94.1	1:16.0
Soils—rural	60	959	4.0	96.0	1:24.0
Decaying wood	51	380	4.1	95.9	1:23.2
Sewage	74	88,700†	41.4	58.6	1: 1.4
Surface water	45	3,920‡	10.5	89.5	1: 8.5

* Based on aggregate content of each source.

† Per cubic centimeter.

‡ Per 100.0 cc.

METHODS

Liquid samples in suitable dilutions were plated directly in cyanide-citrate agar plates and solid samples were suspended in measured amounts of sterile distilled water which was then plated in decimal dilutions. The plates were incubated 42 to 48 hours, and the distinctive type colonies counted directly to obtain (1) the separate Bact. coli count, (2) the separate Bact. aerogenes count, and (3) the combined coli-aerogenes count.

[3] The term "probable Bact. coli" or "aerogenes" refers to the distinctive type of colony as it appears on cyanide-citrate agar. For brevity the word "probable" will hereafter be omitted.

For confirmation, two or more colonies of each type, selected at random from each specimen, were picked with Pasteur pipettes to lactose broth, confirmed as members of the coli-aerogenes group by the Standard Methods,[4] and then tested by four recognized differential methods, viz.: the ferric ammonium citrate agar test, the sodium citrate test, the characteristic colony appearance on eosin methylene blue plates, and the methyl red Voges Proskauer reaction. Impure cultures were repurified before final inclusion in the data.

TABLE 2

The relationship of Bact. coli and Bact. aerogenes colonies as to source

SOURCE	SAMPLES	MEAN			AGGREGATE		
		Per cent		Ratio	Per cent		Ratio
		Coli	Aerogenes	Coli to aerogenes	Coli	Aerogenes	Coli to aerogenes
Feces:							
Human normal	78	96.12	3.88	25 : 1	99.63	0.37	270: 1
Human diarrheal	54	90.60	9.40	9.6: 1	99.60	0.40	264: 1
Human—all specimens	132	93.90	6.10	15 : 1	99.63	0.37	370: 1
Cattle	55	99.85	0.15	666 : 1	99.96	0.04	2,499: 1
Sheep	53	99.59	0.41	243 : 1	99.77	0.23	434: 1
Poultry	54	98.97	1.03	96 : 1	99.47	0.53	188: 1
Swine	52	98.96	1.04	96 : 1	99.79	0.23	434: 1
Horses	57	98.30	1.70	58 : 1	99.85	0.15	666: 1
Dogs	53	95.80	4.20	23 : 1	98.54	1.46	67: 1
All animals studied	324	98.58	1.42	70 : 1	99.42	0.58	171: 1
Human and animal	456	95.10	4.90	19 : 1	99.23	0.77	129: 1
Soils	60	26.4	73.6	1 : 2.8	4.0	96.0	1:24
Cereals	60	18.6	81.4	1 : 4.4	5.87	94.13	1:16
Decaying wood	51	5.4	94.6	1 :17.5	4.13	95.87	1:23.2
Soils, cereals and wood	171	17.4	82.6	1 : 4.7	4.48	95.52	1:21.3
Surface water	45	31.8	68.2	1 : 2.2	10.50	89.50	1: 8.5
Sewage	74	56.4	43.6	1.3: 1	41.40	58.60	1: 1.4

RESULTS

A total of 746 samples representing thirteen different sources of Bact. coli and Bact. aerogenes has been examined in accordance with the procedure outlined. Table 1 briefly summarizes the results in the aggregate.

[4] A. P. H. A. 1925.

The data indicate that numerically Bact. coli as obtained by direct colony count is the organism primarily characteristic of feces; that the Bact. aerogenes type, although found in feces, is numerically insignificant in this source; that Bact. aerogenes is primarily characteristic of soils and vegetation as they are found in nature; that the ratio of Bact. coli to Bact. aerogenes presents a distinctive picture in feces (over 100 to 1), and has a converse relationship in soils and vegetation (about 1 to 20); that the ratio in surface run-off and sewage in the Chicago district points to fecal sources and soil sources as both contributing to the total number of coli-aerogenes organisms present.

Table 2 shows in detail the mean percentage and percentage in the aggregate of Bact. coli and Bact. aerogenes found (1) in normal and diarrheal human feces; (2) in the feces of cattle, swine, sheep, poultry, dogs and horses; (3) in soils; in market cereals, including corn, oats, wheat, barley and rye; in decomposing wood, and (4) in surface water and sewage.

The Bact. coli type of colony was found to be predominant in feces of both animal and human origin almost to the exclusion of Bact. aerogenes. The percentages in the aggregate were 99.23 percent Bact. coli and 0.77 percent Bact. aerogenes, and on the more conservative basis of the mean percentages were 95.1 percent Bact. coli and 4.9 percent Bact. aerogenes. The latter organism was somewhat more numerous in human diarrheal stools than in normal human stools. In soils, cereals and decaying wood, on the other hand, Bact. aerogenes colonies were the predominating type, being present in the aggregate to the extent of 96 percent in soils, 94.13 percent in cereals and 95.87 percent in decaying wood. The corresponding mean percentages were 83.6 percent, 81.4 percent and 94.6 percent, respectively.

Surface waters from the forest preserve districts and sewage from the Chicago river gave evidence of composite sources of contamination in the percentages of 10.5 percent Bact. coli to 89.5 percent Bact. aerogenes for the former and 41.4 percent Bact. coli to 58.6 percent Bact. aerogenes for the latter.

At this point it may be noted that 48.1 percent of 78 samples of normal human feces from 15 different persons showed the presence of Bact. aerogenes. This frequency is in contrast to that indicated by Salle (3) and perhaps is explainable by the greater sensitiveness of the direct plate method and possibly by lower dilutions employed by the latter method.

TABLE 3

Relative frequency and dispersion of Bact. coli and Bact. aerogenes colonies as to source

MAGNITUDE SCALE. AVERAGE OF 1/10 OF ITEMS PER UNIT	NUMBER OF SAMPLES													
	132		324		60		60		51		45		74	
	Human feces		All animals studied		Soils		Cereals		Decaying wood		Surface water		Sewerage	
	Mean percentage													
	Coli	Aerogenes	Coli	Aerogenes	Coli	Aerogenes	Coli	Aerogenes	Coli	Aerogenes	Coli	Aerogenes	Coli	Aerogenes
1	46.10	53.90	79.8	20.2	0	100.0	0	100.0	0	100.0	0	100.0	11.3	88.7
2	93.00	7.00	97.73	2.23	0	100.0	0	100.0	0	100.0	0	100.0	28.5	71.5
3	99.00	1.00	99.29	0.71	0	100.0	0	100.0	0	100.0	0.42	99.58	46.8	53.2
4	99.99	0.01	99.65	0.35	0.6	99.4	0	100.0	0	100.0	1.60	98.40	54.9	45.1
5	100.0	0	99.87	0.12	2.8	97.2	0	100.0	0	100.0	10.80	89.20	58.2	41.8
6	100.0	0	99.96	0.04	6.6	93.4	0	100.0	0	100.0	27.20	72.80	62.0	38.0
7	100.0	0	99.99	0.01	24.1	75.9	3.30	96.7	0	100.0	35.50	64.50	67.6	32.4
8	100.0	0	100.0	0	52.1	47.9	23.03	76.97	0.5	99.5	64.10	35.90	71.5	28.5
9	100.0	0	100.0	0	78.0	22.0	60.17	39.83	6.6	93.4	72.80	27.20	76.8	23.2
10	100.0	0	100.0	0	99.0	1.0	99.77	0.23	48.1	51.9	97.10	2.90	85.3	14.7

Table 3 represents the same basic data as in table 2, grouped for more strict mathematical comparison according to frequency and dispersion of items in order of their magnitude. It transpires, however, that the significant relation of Bact. coli to Bact. aerogenes in the

TABLE 4

Degree of confirmation of Bact. coli colonies by differential tests

SOURCE	EOSIN METHYLENE BLUE AGAR POSITIVE		FERRIC AMMONIUM CITRATE AGAR NEGATIVE	SODIUM CITRATE NEGATIVE	METHYL RED POSITIVE VOGES PROSKAUER NEGATIVE
	COLONIES	Percentage	COLONIES	Percentage		
Feces:						
Human normal	157	96.1	157	94.2	89.2	96.8
Human diarrheal	—	—	98	89.8	78.6	92.8
Human—all specimens	157	96.1	255	92.5	85.1	95.3
Cattle	95	100.0	102	100.0	97.1	100.0
Sheep	110	96.3	110	100.0	98.2	100.0
Poultry	88	98.8	88	98.9	97.7	100.0
Swine	111	100.0	111	100.0	96.4	100.0
Horses	135	98.5	135	98.5	88.1	95.5
Dogs	92	100.0	92	100.0	98.9	100.0
All animals studied	631	97.6	638	99.2	95.6	99.1
Human and animal	788	98.5	893	97.6	92.6	98.0
Cereals	30	93.3	37	67.6	54.1	59.5
Soils*	34	79.4	34	55.8	58.8	91.2
Wood†	10	100.0	10	60.0	60.0	100.0
Cereals, soils and wood	74	87.8	81	61.7	56.7	77.7
Surface water	94	84.0	94	69.1	42.6	90.4
Sewage	88	90.9	96	80.2	47.9	87.5
* Difco-soils			33			90.9
† Difco-wood			11			90.9

various sources is not essentially different as shown by this treatment from that apparent in table 2.

Table 4 indicates the degree of confirmation of the distinctive Bact. coli colonies from all the individual sources when tested by

four recognized differential methods, and table 5 gives the same information with respect to the distinctive Bact. aerogenes colonies.

The degree of confirmation of Bact. coli colonies by all four of the differential tests was very high, and indicates satisfactory correlation.

TABLE 5

Degree of confirmation of Bact. aerogenes colonies by differential tests

SOURCE	EOSIN METHYLENE BLUE AGAR POSITIVE		FERRIC AMMONIUM CITRATE AGAR POSITIVE	SODIUM CITRATE POSITIVE	METHYL RED NEGATIVE VOGES PROSKAUER POSITIVE
	COLONIES	Percentage	COLONIES	Percentage	
Feces:					
Human normal	65	87.6	67	35.8	53.7	38.8
Human diarrheal	22	100.0	22	22.7	68.1	59.1
Human—all specimens	87	97.7	89	32.6	57.2	43.8
Cattle	59	79.6	59	15.2	18.6	16.9
Sheep	18	100.0	18	0	0	0
Poultry	47	95.9	49	0	8.2	8.2
Swine	43	95.6	45	8.9	8.9	8.9
Horses	50	98.0	51	15.7	25.5	19.6
Dogs	50	92.0	52	15.4	26.9	26.9
All animals studied	255	98.0	274	10.6	16.8	15.3
Human and animal	358	91.9	363	16.0	26.7	22.3
Cereals	107	97.2	110	58.1	92.7	89.1
Soils*	77	100.0	83	59.1	97.6	26.5
Wood†	12	100.0	12	91.6	100.0	16.7
Cereals, soils and wood	196	98.5	205	60.5	95.1	59.5
Surface water	78	88.5	79	34.2	68.3	38.0
Sewage	92	86.9	108	40.7	83.3	51.8
* Difco soils			38			73.6
† Difco wood			8			25.0

The confirmations of Bact. aerogenes colonies yielded less satisfactory agreement except with eosin methylene blue agar, which gave exceptionally good results. In general, Bact. aerogenes colonies from feces were confirmed in less degree than Bact. aerogenes colonies

from soil and related sources. This finding appears to be influenced by the predominating type of organism, that is, Bact. aerogenes colonies picked from among predominating Bact. coli colonies often seemed to be atypical Bact. coli, but when picked from an aerogenes setting were usually confirmed as Bact. aerogenes. An exception to this rule was the low confirmation given by the standard technic of methyl red Voges-Proskauer reaction in soils and wood. This led us to retest all the aerogenes cultures from soil and wood by all the confirmatory methods, and to recheck the methyl red Voges-Proskauer results by another technic (Difco medium by the modified procedure of the Digestive Ferments Co.).

TABLE 6

Pearson coefficients of correlation between the cyanide citrate plate differentiation and the confirmatory differential tests*

	EOSIN METHYLENE BLUE AGAR	FERRIC AMMONIUM CITRATE AGAR	SODIUM CITRATE	METHYL RED VOGES PROSKAUER
Cyanide citrate:				
Fecal sources:				
Coli	+0.997	+0.984	+0.925	+0.991
Aerogenes	+0.986	+0.687	+0.545	+0.579
Soil and related sources:				
Coli	+0.974	+0.980	+0.994	+0.855
Aerogenes	+0.999	+0.999	+0.994	+0.838

* Values of 0.5 or above mean decided correlation. Values less than 0.3 indicate poor correlation.

The retests gave identical results for all the differential methods except the methyl red Voges-Proskauer. The latter yielded a much higher degree of confirmation by the "Difco" technic than by the standard technic. However, in second runs by both standard and "Difco" procedures, using the same aerogenes cultures, this reaction gave numerous differences from the first runs. The discrepancies consisted of 28 changes in the "plus and minus" relationships out of 138 aerogenes cultures tested. Our experience with the Voges-Proskauer reaction has led us to place less confidence in it as a test for Bact. aerogenes than in the other differential procedures, although it appears satisfactory as a test for Bact. coli. Possibly the explanation for these discrepancies lies in the presence of a different type of organism, perhaps of an intermediate nature, in soils and wood.

Table 6 shows in another way by means of Pearson (4) correlation coefficients, the degree of confirmation of coli and aerogenes colonies from fecal and soil sources for each of the four differential procedures, and indicates a high degree of correlation in general between the plate

TABLE 7

Net percentage of Bact. coli and Bact. aerogenes colonies as confirmed by differential tests

SOURCE	AGGREGATE PERCENTAGE CONTENT		EOSIN METHYLENE BLUE		FERRIC AMMONIUM CITRATE AGAR		SODIUM CITRATE		METHYL RED VOGES PROSKAUER	
	Coli	Aerogenes	Coli	Aerogenes	Coli	Aerogenes	Coli	Aerogenes	Coli	Aerogenes
Feces:										
Human normal	99.63	0.37	95.7	0.32	93.8	0.13	88.8	0.20	96.4	0.14
Human diarrheal	99.60	0.40	—	0.40	89.4	0.11	78.3	0.27	92.4	0.27
Human—all specimens	99.63	0.37	95.7	0.36	92.1	0.12	84.7	0.21	94.8	0.16
Cattle	99.96	0.04	99.96	0.03	99.96	0.01	97.06	0.07	99.96	0.01
Sheep	99.77	0.23	96.08	0.23	99.77	0	97.97	0	99.77	0
Poultry	99.47	0.53	98.28	0.50	98.38	0	97.18	0.04	99.47	0.04
Swine	99.79	0.23	99.79	0.22	99.79	0.02	96.20	0.02	99.79	0.02
Horses	99.85	0.15	98.35	0.14	98.35	0.02	87.97	0.04	95.36	0.03
Dogs	98.54	1.46	98.54	1.34	98.54	0.22	97.26	0.39	98.54	0.39
All animals studied	99.42	0.58	97.03	0.57	98.62	0.06	95.05	0.97	98.53	0.09
Human and animal	99.23	0.77	97.74	0.71	96.85	0.12	91.89	0.21	97.25	0.17
Cereals	5.87	94.13	5.5	91.4	4.0	54.6	3.2	87.2	3.5	83.8
Soils	4.0	96.0	3.2	96.0	2.2	57.7	2.4	93.7	3.6	26.0
Wood	4.13	95.87	4.1	95.87	2.5	87.8	2.5	95.87	4.1	16.0
Cereals, soils and wood	4.48	95.52	3.9	94.1	2.8	57.8	2.5	90.8	3.5	56.8
Surface water	10.5	89.5	8.8	79.2	7.2	30.6	4.5	61.1	9.5	34.0
Sewage	41.4	58.6	37.7	50.9	33.2	23.8	21.6	48.8	36.3	30.3

differentiation of the two organisms and the confirmatory differential tests.

Table 7 shows the initial percent of Bact. coli and Bact. aerogenes colonies, together with their net percentages as affected by confirmation, for each of the four methods. For instance, the Bact. coli

finding of 99.23 percent by the cyanide-citrate plate for all feces combined, becomes 97.74 percent on a net basis as confirmed by the eosin methylene blue plate test, 96.85 percent by the ferric ammonium citrate test, 91.89 percent by the sodium citrate test, and 97.25 percent by the methyl red Voges-Proskauer test. The Bact. aerogenes finding of 0.77 percent in all feces tested is confirmed as 0.71, 0.12, 0.21, and 0.17 percent, respectively, on a net basis.

TABLE 8

Cyanide citrate intermediate colonies on the basis of the aggregate percentage and net content by the methyl red Voges-Proskauer tests

SOURCE	PERCENTAGE INTERMEDIATES BY	
	Ferric ammonium citrate	Sodium citrate
Feces:		
Human normal	3.2	8.2
Human diarrheal	4.1	14.2
Human—all specimens	3.5	10.5
Cattle	0	2.9
Sheep	0	1.8
Poultry	1.1	2.3
Swine	0	3.6
Horses	1.5	10.4
Dogs	0	1.1
All animals studied	0.4	4.1
Human and animal	1.3	5.9
Cereals	0.8	1.0
Soils	1.4	1.3
Wood	1.7	1.7
Cereals, soils and wood	1.2	1.2
Surface water	2.9	4.6
Sewage	6.4	16.8

The confirmation of both Bact. coli and Bact. aerogenes colonies from feces of all types studied gave exceptionally good net agreement. From other sources the agreement was similar and, though somewhat less than for the fecal sources, showed generally good correlation on a net basis, e.g., usually within 10 percent. In other words, the initial plate differentiation of both organisms in feces was confirmed within a small percent of the whole by the other differential tests, so

that the net confirmed values were not materially lower than the initial findings. The net confirmation of aerogenes colonies was less satisfactory from soil and related sources but, generally speaking, showed reasonable agreement.

Table 8 further classifies the Bact. coli colonies which were confirmed by the methyl red Voges-Proskauer reaction, as shown in table 4, into cyanide-citrate "intermediates" as defined by Koser (5) (6) (7).

It seems reasonable to assume that there may be intermediate groups between Bact. coli and Bact. aerogenes with respect to their reaction in the cyanide-citrate medium. The percentage of such intermediates appears to be small in Bact. coli of strictly fecal origin, and to become greater in Bact. coli from sources remote from feces.

SUMMARY

From these data it appears that the direct plating method with cyanide-citrate agar offers an easy and reliable practical means of obtaining separate Bact. coli and Bact. aerogenes indices, together with the combined group index in the routine examination of water. It also affords a serviceable basis for obtaining the numerical ratio of the organisms to each other.

From the standpoint of water control these data and relationships seem to present new and more exact routine information on which to base sanitary judgment of water supplies. Their practical application demands further study, but their potential value as affording more direct evidence of fecal pollution than has been routinely available heretofore, merits consideration.

The Bact. Coli Index. It appears from the general literature (8) (9) (10) (11) (12) (13) (14) as well as from the data here presented that of the two organisms, Bact. coli is the one derived exclusively from feces, and, therefore, its presence should be more indicative of fecal pollution than that of Bact. aerogenes, which, though present to a small extent in feces, is found in greater numbers widely distributed in nature.

From the standpoint of obtaining more precise and definite evidence of recent fecal pollution, therefore, the routine separation of the Bact. coli index from the group index as a basis for sanitary judgment is desirable if practically feasible.

The Bact. Aerogenes Index. In feces Bact. aerogenes, although present to a degree, is numerically insignificant in the aggregate. The organism appears to be principally of non-fecal origin, although

it is regarded by some authorities (15) as probably derived from fecal sources. Its general distribution, however, in far greater numbers than the assumption of direct fecal origin can account for, tends to destroy its value as definite evidence of recent fecal pollution. Its presence in water apart from Bact. coli probably has little practical sanitary significance.

The Combined Coli-Aerogenes Index. The coli-aerogenes group index, depending as it does on a truly fecal organism combined with an organism probably not exclusively of fecal origin, seems necessarily to be of less value as a definite fecal test than is the Bact. coli index alone.

Practically speaking, the inclusion of Bact. aerogenes with Bact. coli in an index on which to base sanitary judgment, tends to render that index less indicative of dangerous fecal pollution and, therefore, less dependable as a criterion of such pollution.

From the standpoint of eliminating extraneous or perhaps even misleading evidence, it again appears desirable to separate the Bact. coli index from the Bact. aerogenes index in routine practice if possible.

The Ratio of Bact. Coli to Bact. Aerogenes. The ratio of Bact. coli to Bact. aerogenes in strictly fecal sources of all the types studied, presents a distinctive picture as determined by direct count. It is greater than 100 to 1 in the aggregate and is approximately 20 to 1 on the more conservative basis of the mean percentages. A converse ratio obtains in soils and related sources. In urban sewage the ratio approaches 1 to 1. In rural surface run-off Bact. aerogenes predominates.

These ratios in the sources of pollution of water supplies tend to support the view that Bact. aerogenes is significant of fecal pollution only when accompanied by Bact. coli; that a considerable excess of Bact. aerogenes over Bact. coli points to surface contamination rather than to direct fecal pollution; and that Bact. aerogenes when present apart from Bact. coli suggests extraneous contamination of non-fecal origin.

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DISCUSSION

S. A. KOSER:[5] Dr. Tonney and Mr. Noble have presented a very interesting series of results obtained with their cyanide-citrate agar. Any direct plating medium which gives promise of differentiation of the characteristics fecal coli from other related lactose-fermenting organisms is well worth intensive study of those interested in the problem of water examination.

In the past, one of the chief drawbacks to the use of the differential tests (methyl red test, Voges-Proskauer reaction, sodium citrate medium, etc.) has been the necessity of applying them after enrichment of the sample in lactose broth or some similar liquid medium.

[5] Department of Hygiene and Bacteriology, University of Chicago, Chicago, Ill.

Obviously, the original proportions of the organisms may be greatly altered by multiplication in such a medium. This fact alone has undoubtedly been sufficient to discourage the use of differential tests by most water analysts, and probably more than anything else has contributed to the impression held by many that the differential tests are of little practical value.

The cyanide-citrate direct plating medium gives promise of overcoming this difficulty and while its value can be determined only after numerous trials under different conditions, nevertheless the results obtained with it so far appear to amply justify further study. In addition to its possible application in routine water analysis, the medium offers obvious advantages for fundamental studies on the natural distribution of the members of the coli-aerogenes group.

WAUKEGAN FILTRATION AND PUMPING PLANT[1]

By Henry A. Allen[2]

The City of Waukegan has awakened to the advantages of its location on the Great Lakes and the possibility of rapid increases in population and commercial importance. Many of its citizens have come to realize that living conditions are important factors in expansion and, of these, that a good water supply is a prime condition. To this end an up-to-date system of water supply was authorized by this city, the main portion of which, the filtration and pumping plant, is now in successful operation.

The plant is situated on a peninsula at the north entrance to Waukegan Harbor. For a practical as well as artistic effect, the front faces the south, where it can be plainly seen from sea and shore. At present a 24-inch inlet main, installed several years ago, extends in an easterly direction into the lake, the outer end being about 3,000 feet from the shore in a depth of water about 25 feet.

As the deep water is in a south easterly direction it was decided, on grounds of permanency and reliability, to construct a shaft south of the south Government Pier, it being provided with two openings, one connected to the present 24-inch inlet pipe and the other available for connection, should it be deemed advisable to install a second inlet main extending farther into the lake. This shaft is connected by a tunnel running under the harbor entrance, to the wet-well shaft in the plant. An emergency intake is provided for use in case of trouble in the present intake.

The plant is designed on the duplex plan, so that when required either half may be run. Arrangements are provided to permit crossing over units of each half. The raw water pumps discharge through two parallel Venturi meters, one for each side, into cast iron grit chambers, from which the water flows into the primary aerator channels.

[1] Presented before the Illinois Section meeting, May 14, 1929.

[2] Consulting Engineer, Allen and Vogtborg, Inc., Chicago, Ill.

SPECIAL FORM OF AERATOR

Aeration is now well recognized as a beneficial adjunct in the purification of various water supplies. In the design of the Waukegan plant it has been endeavored to obtain efficient aeration at the least cost of operation. A special form of aerator has been devised by its engineer.

Air, practically at atmospheric pressure, is sucked in by the water flowing past hundreds of tube ends and the mixture of air and water discharged about 20 feet below the surface of the water in mixing chambers. The air being under pressure equivalent to the head of water and its gravity being about one eight-hundredths that of water is rapidly forced to the surface, thereby causing three important actions—first, agitation or mixing; second, mechanical carrying off of odors on its release at the water surface; and third, because of the intimate mixture with the water, enabling a maximum amount of oxidation to take place in the available intervals of time.

If the descending column of water with its contained air is supplied with a chemical, on reaching the lower end of the pipe, the air so to speak is released from the water column, and rapidly rising causes violent agitation resulting in elimination of mechanical mixing devices.

This system of aeration does not require a large area, which if not covered permits exposure of the water to the direct heat of the sun in the hot months and to the effects of cold during the winter.

The air used for aeration can be readily pre-washed and further can be chemically charged, if desired.

On discharge at foot of aerator pipes, the water and air pass through specially designed baffled mixers. From above the mixers much of the air is liberated, the water passing down to the bottom of respective covered sedimentation basins. During the 3½ hours in the coagulating basin excess entrained air is freed. From sedimentation basins the water passes into settled water channels and from there through 8 feet wide by 28 inches high sluice gates to filter beds. The settled water channels are 8 feet in width, thus permitting low velocity from sedimentation basins to filter beds.

FILTER BEDS

The filter beds are ten in number, five on each side of the filter gallery. Each bed has a nominal capacity of one m.g.d. equivalent to one cubic foot of water per minute per 4 square feet of area.

Each of these filters is provided with an underdrain pipe system of special design, consisting of a cast iron header set in the front wall of the filter. From the header 20 tubes project across the filter bed in the bottoms of triangular troughs.

The tubes are provided with $\frac{1}{8}$-inch holes, properly spaced to allow for differences of velocities in various portions of each tube. The problem is one of velocity of water through an orifice in a thin plate.

To ensure integrity of the holes throughout a long period of years, the tubes are made of bronze. Each filter is provided with a completely equipped control table, each table being provided with substantial push buttons for the operation of wash water pumps.

FILTER APPURTENANCES

The pipe gallery is provided with two complete sets of wash water and drain piping, thus completely carrying out the duplex plan system. Beneath the filters and the pipe gallery are situated the clear wells. These clear wells are connected to a clear well main between the two covered filtered water storage reservoirs, one on the outside of each sedimentation basin. By means of proper valves one or both clear wells may be discharged into both or either of the storage reservoirs.

Special floats and hydraulic regulators are provided to maintain practically constant head in sedmentation basins and filter beds.

Automatic devices are provided for decreasing the rate from a certain predetermined level and cutting off the flow from filter beds when a predetermined maximum elevation has been reached in the reservoirs. At each end of the clear well main is provided a small basin which connects with the secondary aerator channel.

There are two chlorine booths provided, one on each end of the main pipe gallery, each being provided with two chlorine machines. These machines are situated above the wells at each end of the clear well main, the piping leading directly down and the chlorine being discharged into the outlets of the clear well main.

The secondary aerators are similar in construction to the primary aerators and as the chlorine is applied to the water before reaching these aerators, the chlorine is perfectly mixed when discharged through the aerators into the storage reservoirs.

From these points the water travels between concrete baffle walls to prevent short circuiting and stagnation, a distance of 1000 feet before entering the suction main between the two filtered water stor-

age reservoirs. This gives ample time for the release of excess entrained air and residual chlorine.

Provision has been made for split chlorination, should this be found in actual operation to be necessary.

The plant has been designed for the use of alum for coagulation, but can be readily equipped for other forms of treatment if desired.

Among the special features are the loading platforms, at each end of main pump room, one for receiving the chemicals and supplies, the other to enable a truck to back in under electric hoist on a hand operated traveling crane.

Over each bank of filters is provided a traveling crane with electric hoist for convenience in handling gravel and sand and guarding against all damage to the appearance of the filter gallery when such material as often the case is handled by wheel barrow and bucket over the filter gallery walls or railings. An automatically controlled safety elevator is provided to run from the pump room floor to the chemical and other floors and loading platform.

SOURCE OF POWER

The power will be supplied by the Public Service Company of Northern Illinois which company has entered into an arrangement with the City of Waukegan to permit tapping to each of two main trunk lines connecting their two large power plants situated in Waukegan. The cables lead through two 6-inch wrought iron pipes underneath the Waukegan Harbor and into the plant at a voltage of 12,000. Both the high tension and low tension switch gears will be of the Reyrolle type. Two banks of transformers are provided, the switch gears being provided with a selective switch so that in case of anything happening to one of the main power lines, the other bank of transformers is immediately cut in. A hydraulic gauge board is provided for control from the main gallery of hydraulically operated gate valves. On the main gallery are also situated the recording devices of both raw water and discharge Venturi meters. A gauge board containing the various level gauges is provided on the main gallery at the end of the filter gallery for convenient observation.

OFFICES AND SHOPS

An office for the superintendent and a roomy well equipped laboratory are situated on the chemical floor.

There are provided a well equipped machine shop suitable for making ordinary repairs, necessary locker rooms, lavatories, store rooms,

fuel and oil storage tanks, coal storage room and station heating plant with complete equipment capable of using either coal or oil for fuel.

The architecture of the building is of a plain, substantial type. The brick work is seal brown in color with raked joints. The trimmings are terra cotta of light gray stone color. To hold the sand and for convenience in maintaining cleanliness around the plant there are provided suitable concrete roadways and walks. The top of the filtered water storage reservoirs will be earth covered and sodded. The grounds in the vicinity of the plant will be filled to smooth surfaces so as to give a park effect and enhance the beauty of the entrance to Waukegan Harbor.

SPECIFICATIONS

My specifications required leakages on tests of sedimentation basins, reservoirs, clear wells and filter beds not to exceed one inch in seven days at normal working levels.

The final tests resulted as follows:

Filter beds: (Depth of water 7½ feet)
  ⅜ of an inch leakage in seven days
Clear wells: (Depth of water 10 feet)
  East: ¼ of an inch leakage in 30 days
  West: ⅝ of an inch leakage in 24 days
Reservoirs: (Depth of water 16 feet)
  East: ¾ of an inch in 27 days
  West: ⅞ of an inch in 27 days
Sedimentation basins: (Depth of water 20 feet)
  ⅝ of an inch in 7 days

Head-capacity charts have been made out for reservoirs, sedimentation basins, clear wells and chemical tanks based upon careful instrument measurements made after all were subjected to maximum water pressures. This will enable accurate tests of equipment and various forms of water treatments to be readily made when required.

It is expected that certain additional water treatment apparatus will be installed after the plant has been in operation sufficient time to permit proper conclusions to be drawn from the records of operations.

COKE PLANT WASTES

After the plant was under construction the city permitted the Baehr Coke Company Plant to be erected approximately 1200 feet north of the filtration plant. The city made no stipulations as to the treatment of plant wastes.

On being informed of the location of a coke plant in close proximity to the filtration plant the writer called the attention of the city officials to the necessity of preventing wastes being run into a small lake made by a shallow excavation in the sand within the property lines of the coke plant. The outside edge of this lake was approximately less than 100 feet from the lake shore. The writer held it would not take long before the sand spit upon which the filtration plant is located would be impregnated with phenols.

On January 9th the plant was started. On the 15th and intermittently up to January 28th strong amounts of phenol entered the city intake which is approximately one-quarter of a mile from the aforesaid mentioned phenol tainted lake. Since the 28th there has practically been no recurrence of the phenol tastes.

I have recommended that the city compel the coke company to cease contamination of its water supply.

ASBESTOS WASTES

It will be further interesting to note that after operating for a considerable time a darkish substance of sufficient gravity not to be carried over into the waste water troughs accumulated more or less over the surfaces of the sand beds. This coating apparently does not interfere very much with the rate of filtration.

An examination of the sedimentation basins shows an astonishing amount of this material deposited in same, but a comparatively small mount reaching the filter bed.

Examinations so far made indicate that this material consists of fine particles of asbestos and other wastes from the Johns Manville plant situated approximately one mile north of intake, possibly mixed with certain tannery wastes.

If all the citizens of Waukegan could see what the water supplied them contained before the operation of their new filter plant it would certainly be a great surprise and should make them thankful for the great betterment of their domestic water supply.

MISCELLANEOUS INFORMATION

The plant was paid for by funds received from the sale of water certificates issued in accordance with the laws of the State of Illinois.

In designing the plant the writer endeavored to fully meet the requirements of the National Board of Fire Underwriters to obtain the lowest fire insurance rate.

The present pumping capacity is 20 million gallons per 24 hours, consisting of four low lift and four high lift electrically driven centrifugal pumps, each of 5 million gallons capacity.

The filtered water storage capacity of the plant is about 4,200,000 gallons.

By additional filters and installing larger pumping capacity which can readily be done the plant can be increased to twice its nominal capacity of 10,000,000 gallons per 24 hours. This will be equivalent at the rate of 200 gallons per capita for the supplying of a population of 100,000, the present population being about 32,000.

I have always believed a water supply system should be designed for a capacity considerably in excess of the maximum demand. Unfortunately engineers are often too closely limited, as to best capacity, due to various reasons principally inefficient funds. The officials of the City of Waukegan are to be congratulated for their foresight in authorizing the construction of a filtration and pumping plant sufficient at the present time to supply double the present population.

The work was done under the Department of Public Property and Parks, Mr. Robert J. Pearsall, Commissioner.

The writer was consulting and designing engineer. Mr. James Ashworth was field engineer for the city.

Cope & Fisher, Decatur, Illinois, were Contractors for Sections, A-C-E-F and G and did the work of construction on Section A, designated "Provide and Furnish Filtration Structures." The following Sections were sublet by Cope & Fisher:

Sections C and G. "Furnish and Install Station Piping, Valves and Fittings, Special Apparatus and Castings" and "Install Heating System," respectively, to Ashton & Russell, Chicago, Illinois.

Section E. "Furnish, Deliver and Install Filter Appliances," to E. C. Bacharach & Company, Kansas City, Missouri.

Section F. "Install Station Light and Power, Wiring and Station Lighting System," to Krigbaum Electric Company, Decatur, Illinois.

George A. Green, Green Bay, Wisconsin, was Contractor for Section B—"Furnish Material and Install Subaqueous and Other Piping and Make Connections."

Allis-Chalmers Manufacturing Company, Milwaukee, Wisconsin, was Contractor for Section "D"—Furnish, Deliver and Erect Electric Power and Pumping Equipment, Appurtenances and Accessories."

The plant was officially put in operation on January 9, 1929, and since that time has been in continuous, successful operation.

AUTOMATIC PUMP STATION CONTROL[1]

By J. W. Robinson[2]

The invention, manufacture and installation of labor saving devices and machinery is the aim of all progressive business today. Keen competition demands that better service be given and at lower cost. Lower cost can be obtained by more efficient machinery and by the installation of automatic control to replace attendants.

With the electrical and mechanical automatic control devices now perfected and on the market, almost all water works routine work can be turned over to an automatic watchman, who if regularly cared for never sleeps, makes no mistakes, starts and stops on a second's notice. He never grumbles, never complains; does not agitate and cause strife among his fellow workers; nor does he strike for more pay.

The politics of small municipalities and the civil service regulations of the larger cities make it difficult for a water superintendent to keep close supervision and control over his water system. A partial relief from this burden may be obtained by the installation of automatic control equipment.

There are hundreds of installations of automatic pumping stations in successful operation. They range in size from a one-eighth horse power, motor-driven, automatic home water plant to a 70,000,000 gallon per day centrifugal pump, under 170 foot head, driven by a 2600 h.p. synchronous motor and operated by remote push button control.

There are on the market automatic compensators for starting all kinds of electrical equipment, which require only a push button station to control them. This push button station may be at any distance from the place of operation. For example, the President of the United States pushed a button and blasted a hole through the Cascade Mountains.

For the automatic control of pumping equipment the only thing that remains a problem is the selection of the proper devices to act

[1] Presented before the Pacific Northwest Section meeting, May 17, 1929.

[2] Civil Engineer, Water Division, Spokane, Wash.

as push button start and stop for the electrical equipment. The water supply must not fail.

The most common method of automatically starting and stopping electric-driven pumps where there is no danger of freezing of the water surface, is by the use of a float which operates a quick make and quick break switch. This switch carries the full current if the motor is small or operates a relay if the motor is large.

Where there is danger of freezing, a pressure gauge in a frost proof vault is used, which registers the height of a column of water. Electrical contacts which operate through the needles of the gauges are built so they may be set at the desired high and low limits of the water in the tank. When the needle makes contact with the contactor, a small rush of current operates the relay which has sufficient current carrying capacity to act as a push button to operate the automatic control board.

Where the pressure gauge can not be attached to the tank but must be placed on the discharge piping, it may be necessary to install apparatus consisting of an air chamber, damping discs, and needle valves ahead of the pressure governor to prevent rapid fluctuations in pressure which cause spasmodic starting and stopping of the motor.

Instead of a pressure gauge, a mercury column may be used in which a float and rod with contact arm are set to correspond to the high and low levels required in the tank. With this device connected to the tank the water level can be controlled within a few inches of the desired high and low levels.

Where the tank is located some distance away from the pump station, possibly a mile or more, and there is distribution taken off from the pipe line, it is necessary for sccessful automatic control to run signal wires from the pump station to the control device at the tank.

Where the use of water is fairly constant and there is no need for starting in case of small fires, and where it is not practicable to install a float or pressure switch, a time clock may be used to advantage. The attendant in making his round can anticipate the demand and set the clock accordingly.

Many ingenious schemes have been developed to transmit water elevations from distant reservoirs. The problem consists of converting the mechanical motion of a float or a gauge into electrical current, transmitting it to the pump station, and converting it back into

mechanical motion. The electric current at the station may be used to control one or several electric pumping units pumping to the reservoir.

The flow meter may also be used as an automatic control for a pumping station on a dead end water system, (a system without a tank). One small pump is run continuously to supply the minimum demand and maintain the pressure. Whenever the flow is increased the flow meter automatic controlling device starts additional pumps and keeps the proper number in service to supply the water and maintain the pressure.

In a system with a varying demand, pumps can be installed in stepped sizes. With three pumps, for example, with an automatic control system, the three pumps can be started in six different predetermined combinations. As the load comes on the combinations can be made to pump at maximum efficiency and with a minimum power demand.

In the successful operation of an automatic pumping station, due to the varying conditions, a combination of control devices may be required. It may be necessary to start on a pressure switch at the station and stop with a pressure or float switch at the tank, or start with a pressure switch and stop with a time clock.

The automatic stations pumping from wells and on booster service require periodic inspection by a skilled operator, who can take care of at least one dozen 50 to 300 h.p. stations and with an assistant keep the stations and equipment in first class condition.

The pumping and control of water lends itself well to automatic and remote control. When the old equipment now in use has finally been discarded and new equipment is installed, the water superintendent, except in the largest cities, will have all pumping stations and reservoir data on charts and graphs in his office and will have remote control push button stations for controlling motors which are not automatic. The stations will receive periodic visits from an inspector.

The city of Spokane water system serves water through an elevation of 740 feet, ranging from 190 feet below to 550 feet above the source of supply. It is served by five pressure systems: Low, North Hill, Intermediate, Woodland Heights, and High.

The water system has grown, keeping in step with the growth of the city and the development of waterworks equipment. Standpipes

and pump stations have been built and served through their years of economical life and have been abandoned. The changes in the distribution of water served and the increased load has presented problems which are being successfully and economically handled by the installation of automatic booster stations.

Spokane has in operation four booster pumping stations with five pumping units, each unit in care of an automatic electrical watchman.

METER READING[1]

By Walter C. Bowen[2]

It is the function of the assessment bureau to read meters, to verify readings when found necessary and to make estimates of consumption of water whenever for any reason a meter cannot be read, or where a meter is found to have stopped registering. The Bureau prepares the figures on each account for billing of the Department's 255,000 accounts. It handles all complaints pertaining to high bills, including receiving and answering all correspondence relative to same. It makes an assessment of all unmetered usage of water, such as old property where a meter has not been installed and where water is used for construction purposes.

Bills are prepared and the activities are supervised of the addressograph room, where bills are printed, addressograph plates are prepared or altered, forms printed for use in the various bureaus of the Department and waste cuttings of paper are padded for use.

The personnel of the Bureau consists of:

1 Supervisor
1 Assistant Supervisor
3 Foreman
1 Meter Inspector
13 Clerks
1 Stenographer
5 Addressograph Machine Operators
47 Meter Readers grouped as follows:
- 1 with a car equipped to pump water out of wells.
- 2 for special meter readings.
- 1 for reading meters after hours, such as nights and Sundays.
- 6 for pick ups that were not read the first time over. This amounts to about 10 percent of the readings.
- 6 delivering bills.
- 31 for regular reading.

Since about two readers are absent each day, it is necessary to change some of them from one group to another and in some cases one

[1] Presented before the Central States Section meeting, September 20, 1929.

[2] Supervisor of Water Assessment Bureau, Department of Water Supply Detroit, Mich.

or two are brought into the office to help out when and where needed to keep up the schedule.

READING METERS

The present method of reading meters was put into effect in March, 1926. The city is divided into three zones of approximately the same number of meters, one zone to be read each month. Each zone is then divided into twelve districts, two days being allowed to read each district. Districts are divided into routes of one day's work for each reader. The average number of routes per district is about 47.

The reading slips for each route are placed into a specially constructed reading book and locked. It is never unlocked except to add new slips. The average number of reading sheets per book is about 165.

Reading slips are designed to last six years, showing the reading each quarter and consumption.

Readers report to the Bureau only in the morning, leave their work read the day before and receive that assigned to them for the day. They are compelled to finish their books each day, no excuses being accepted except for sickness or accident. If interrupted by bad weather they complete the day by appearing at the office where work is assigned to them.

Readers make the subtraction from former reading and extend the quarterly consumption.

They are required, where a much lower consumption is indicated, to test and report stopped meters. Where a much higher consumption is shown they are required to ascertain the cause, if possible, reporting same on reading slip and to occupant where a wastage is found. They report all new buildings as they become occupied, being the only men in the Department that cover the entire city regularly. They are expected to report any and all violations of the Department's rules.

Before the present system of reading meters was installed in 1926, the average day's reading per man was 110, it is now 165.

PREPARING READINGS FOR BILLING

The schedule requires that the reading books of each district be ready for billing eight days after date of reading. The books that are turned in each morning are a long way from being ready to bill.

Each reading is examined by clerks for possible mistakes. Consumption is checked with past and present reading. Slips are made out for a second call on unread meters and check readings. Job cards are made out for stopped meters and sent to the meter repair shop. Pick-ups and night readings on former slips are entered.

A semi-monthly record is compiled of errors or omissions made by each reader, which is an incentive for improvement.

HANDLING COMPLAINTS

This problem requires a great deal of patience and tact. It is accomplished by the assessment bureau with a minimum of failure.

About 1200 complaints are handled each month, some 400 of them being by mail. Approximately 375 are disposed of by obtaining a re-reading and inspection of premises for leaks. A letter is written informing the consumer or owner of cause in each case where a re-reading is obtained, or a letter received. A point is made to answer each communication whether it is a 6 page letter or a few lines on the stub of the bill.

The balance are disposed of by quoting notations furnished by meter reader, or the explaining of some other obvious cause.

However, a failure is reported on about 4 per month by referring them to the Adjustment Committee of the Water Board.

NEW ACCOUNTS

When new service lines are installed a reading slip is made out and placed in it's proper place in the readers route book. On this slip the street number, lot number, size of service and date installed are shown.

A construction service charge is made on each $\frac{3}{4}$-inch service line of 0.75 cent per month until the meter is installed, but not to exceed four months. Then, if for any reason a meter has not been set, a minimum bill of $1.25 per quarter is charged until metered.

The same plan is applied on 1 and $1\frac{1}{2}$-inch service lines, with the exception that $1.50 per month is made for the first 4 months period and thereafter the regular service charge prevails until metered.

Larger lines carry the customary service charge, plus water used for construction, based on the construction tax schedule as to material used.

SAFEGUARDING WISCONSIN'S WATER SUPPLIES[1]

By L. F. Warrick[2] and O. J. Muegge[3]

When we speak of the quality or purity of water supplies many persons think only of a clear, cold and at least apparently clean water which sparkles when drawn from a faucet and has no objectionable taste or odor. Those better informed think of the quality of the water not only in terms of its physical characteristics but also with regard to its bacterial content, or freedom from disease producing impurities. Those of us who are supervising or operating either private or public water supply systems must go one step further and consider the quality of the supplies in terms of providing best available protection against even the remotest possibility of pollution detrimental to the health of the water consumers. The object of this paper, therefore, is to present and discuss some of these protective measures in safeguarding Wisconsin's water supplies.

Obviously it will be impossible to discuss all sanitary considerations entering into the construction or maintenance of water supply systems. A general summary is presented, therefore, with special attention to the following items:

(1) Prevention of pollution of ground water supplies.

(2) Effective water purification.

(3) Adequate protection against water borne disease epidemics from faulty cross connections.

Any pollution entering a water supply constitutes a serious menace to the public health of a community because the people, through false sense of security, may place complete dependence in the purity of the supply. It is the unknown danger that is most serious. Sources of possible pollution must be sought and guarded against.

To assist in this work the State Board of Health has adopted the policy of inspecting municipal supplies regularly, as follows:

(a) Surface and other supplies with sources of questionable character are inspected annually.

[1] Presented before the Wisconsin Section meeting, September 18, 1929.

[2] State Sanitary Engineer, State Board of Health, Madison, Wis.

[3] Assistant Sanitary Engineer, State Board of Health, Madison, Wis.

(b) Shallow well and questionable deep well supplies, every two years, and

(c) Satisfactory deep well supplies every three years.

This procedure has been quite consistently followed, and it is believed that very good check on the quality of the supplies has been maintained especially in conjunction with the interim control afforded by the routine analyses of surface supplies monthly, shallow well supplies quarterly and deep well supplies semi-annually. Unfavorable analyses are followed up by communication with officials and by special investigations if believed necessary.

In short the object is to anticipate trouble and coöperatively to secure improvements to safeguard the water supplies before an epidemic of water borne disease is experienced.

PROTECTION OF GROUND WATER SUPPLIES

Drilled wells assume an important place in the water supplies of Wisconsin since of the 283 municipalities or communities having a waterworks, 252 secure their water supply from ground water sources, 212 of these supplies being obtained all or in part from drilled wells, the population so served being 572,400 as based on the 1920 census. Furthermore, it is conservatively estimated that 75 percent of the state's population not served by municipal waterworks systems secure their water supply from drilled wells, making the total population served approximately 1,500,000.

Such drilled well supplies, therefore, undoubtedly have a marked effect on the typhoid fever death rate of the state, which for 1928 was 0.8 person per 100,000 population, the lowest rate ever obtained for this state and one of the lowest in the United States. This is a record of which we may be proud, but instead of resting on past accomplishments let us all do our part to cause a further decrease by the proper development and control of public and private water supplies from the sanitary point of view.

In the development of safe ground water supplies three main factors must be considered:

(1) Satisfactory location with respect to pollution sources.

(2) Proper well construction, and

(3) Correct pump connections.

The first two of these factors are more or less interrelated, and although primarily constituting a part of the well drillers' duties should also concern the waterworks official. The third pertains to

the driller only in so far as making the completed well installation such that the pump connections may be made in the proper manner.

A common fault in the development of a large number of private and also municipal wells is their improper location with respect to surface drainage, flooding during times of high water and proximity to sources of surface or sewage pollution, such as streams, sink holes or crevices, abandoned uncapped wells, sewers, privy vaults, cesspools, or other devices for sewage disposal by soil absorption. Failure to heed the proximity of such pollutional factors has resulted in a considerable number of typhoid fever and gastro-intestinal epidemics.

In order to give due consideration to proximity of sources of pollution it is necessary to have knowledge of the extent and direction of travel of under ground pollution and its relations to the ground water level. Up until a few years ago the distance to which pollution may travel underground and other factors involved was largely a matter of guess work which consequently was the cause of widely varying opinions on the question. During the period from October 4, 1921 to June 23, 1925, however, the United States Public Health Service made a series of experiments on the extent of ground water pollution at Fort Caswell, North Carolina, and published the results in Hygienic Laboratory Bulletin No. 147, entitled "Experimental Bacterial and Chemical Pollution of Wells, Via Ground Water and the Factors Involved." This Bulletin, published in 1927, provides the most authentic and comprehensive data on this subject.

The experiments definitely established the following facts:

(1) That pollution travels only in the direction of the flow of ground water, B. Coli, an intestinal germ, having been recovered at a distance of 232 feet, and uranin, a dye, at a distance of 450 feet from the source of pollution.

(2) That the zone of pollution at any well is that portion located between high and low ground water levels, or when considering surface water contamination the danger zone is from the surface to the lowest ground water level.

(3) That as pollution travels it does not expand laterally, (in a fan shape) but rather gradually contracts to breadths narrower than that of the pollutional source.

These experiments were conducted in a rather fine sandy soil, effective size 0.14 millimeter, and where the rate of ground water flow was estimated at slightly less than one foot per day. Given a more porous soil with a more rapid under ground flow, (a rate of 450 feet per day having already been recorded) and knowing that typhoid bacteria have a viability, or possible period of existence of

up to five and one half months and B. coli of at least two years and eight months, it is impossible to estimate to what distance sewage pollution will ultimately travel.

Consideration must also be given to the effect of varying pumpage upon wells since the drop in ground water level, known as drawdown, is essentially proportional to the yield. The cone of depression which accompanies such drawdown tends to reverse the ground water flow toward the well, the area of depression extending further in the direction of the normal under ground flow. In case of private wells where only a relatively small quantity of water is withdrawn the cone of depression will be of relatively small extent, but with municipal wells where the pumpage varies from 50 to 1000 or more gallons per minute the cone of depression will cover a considerable area.

In locating a well, therefore, all sources of pollution in the neighborhood should be carefully investigated and serious consideration should be given to determining the probable direction of underground flow and also the extent to which pumping may change such direction. Generally in the mantel or surface deposits, the normal underground flow will be approximately toward any adjacent stream, pond or lake, or essentially parallel to the slope of the ground surface. Some exceptions, however, exist to this general rule, and too much dependence should not be given to surface topography. If definite assurance or actual data are obtained as to the direction of the underground flow the well can be properly located in reference to known sources of pollution so that a line through these sources parallel to direction of flow will not intersect the well. Where the direction of flow is unknown, distance from the well represents the best factor of safety, since the further the well is from sources of pollution the less is the probability of the ground water flow intersecting both the pollutional sources and the well.

In rock foundations, particularly creviced rock, the direction of underground flow cannot be readily determined, and so greater care must be taken in the construction of the well itself, since pollution gaining access, particularly in limestone, through sink holes, outcrops, and mine shafts may be conveyed for long distances, measurable even in miles, through crevices, solution channels, and caves. Where the well extends into a compact rock formation, with an impervious layer between it, and the surface formation, a different condition of underground flow than is present in the mantle or surface deposit occurs, and the zone of depression in the rock formation is generally

independent of the water level in the surface strata. In order to protect against the pollution of such wells comparatively little attention need be given to the flow in the rock strata, but should be confined largely to the direction of flow in the surface formations.

In the construction of the well the danger zone, as previously stated, is that portion of the well lying between the surface and the lowest point of the ground table. In protecting wells against pollution, therefore, special attention should be given not only to surface protection, as is now generally recognized, but also to the construction in this danger zone. Leaks, improper seals, or insufficient depth of casing, in this region are potentially very dangerous and all wells improperly constructed or protected in this danger zone must be considered as potentially unsafe. All wells should be cased to a point below the lowest probable ground water table and where such well extends into the rock the casing should be thoroughly and permanently sealed into a hard, compact, uncreviced rock formation. Again special attention should be given to the casing in limestone formations, and generally all formations of this character should be thoroughly cased off, particularly in the case of municipal wells.

Wells extending into rock, furthermore, are more potentially dangerous than wells ending in deep gravel or sand formations, since the diameter of the drilled hole is normally larger than that of the casing, thereby causing an annular opening between the rock formation itself and the well casing. Unless casings are properly sealed into a compact formation the water which gains access to this annular space, due to less resistance to flow, will be drawn into the well more rapidly than water entering through the formation itself. If, therefore, definite assurance may not be had that a perfect and permanent seal is obtained, this annular space should be filled with cement grout so as to close the direct channel. The grouting of this space is desirable even if a perfect seal is obtained, especially in municipal well supplies, since it protects against corrosion in the danger zone. All casing should be of the best wrought iron pipe available since such casings assure better protection against the corrosive action of some ground waters.

A well when completed should have the casing project above the normal ground surface of the proposed pump room floor to a distance of at least 6 inches so that a proper connection with the pump column may be made. Experience has shown the desirability of making such a water tight seal preferably by use of flange connections

so that the possibility of contamination at the surface will be minimized. Well casings should preferably not be used as part of the suction lines for suction pumps or as reduction pipes for air lift pumps, since possibility of deterioration of the well casing will be increased thereby. Well pits or pump rooms below ground level should be avoided wherever practicable and the pumps installed on a properly drained concrete floor or curb located above the surrounding ground level.

Upon the completion of a well, samples should be collected and analyzed by the State Hygienic Laboratory. Inasmuch as the drilling operations tend to contaminate the water, sterilization of the well prior to collection of the sample is desirable. This can be done by using calcium hypochlorite, liquid chlorine, B.K. solution or some other sterilizing agent. As such chemicals as chlorinated lime lose part of the available chlorine on standing, a fresh supply should be obtained. The procedure of sterilization is as follows:

Estimate the volume of water standing in the well which can be determined readily from the following table:

Diameter of well in inches....	4	6	8	10	12	15	18	24
Gallons per foot of depth.....0.6	1.5	2.6	4.1	5.9	9.2	12.2	23.5	

Then for each 1000 gallons of water use one to 1½ ounces of chlorinated lime. This material is usually sold in 12 ounce cans and one tablespoon (powder about one inch deep in center) weighs approximately one ounce. Rub up the powder necessary with a small amount of water to make a thin paste, taking care to break up all lumps, and stir this paste into a bucketful of water. Let the mixture stand for a short period and pour the clear top liquid into the well. Agitate the water in the well to insure mixing and allow the water to stand at least several hours so that the chlorine may take effect. Then pump the well thoroughly, taking due precaution to prevent the water from going back into the well, using the pump from which the sample is to be collected. The procedure of collection of samples is carefully outlined on the blank date sheet sent with the sample bottle container.

Where there is some reason to believe that contamination of an existing well may occur it is advisable to provide chlorination of the supply as an additional safeguard. The cost of such treatment is nominal and will constitute in many cases cheap insurance against typhoid and other water borne disease epidemics.

EFFECTIVE WATER PURIFICATION

Of the 283 communities in Wisconsin with public water supplies, 31 secure water from surface sources through 26 waterworks systems,

serving a total population of about 760,000. Only one of the 26 sources is without purification, 12 utilize chlorination only, and 13 have complete purification plants. It is desired to emphasize here that chlorination of surface supplies does not always constitute adequate protection against disease producing impurities. Waters having a fluctuating organic content or receiving varying amounts of wastes which have a chlorine absorbing power, are always open to suspicion when chlorination alone is depended upon, since sufficient free, or residual, chlorine must be present in the water long enough to insure sterilization of the supply.

The need of proper attention to details in the operation of water purification plants has previously been given considerable discussion, and there is no need to review the subject here. For the most part operating results with water filtration plants in the state have been entirely satisfactory.

CROSS CONNECTIONS

The responsibility of municipal and waterworks officials does not end when the water supply has been secured from a safe source or adequately purified, since protection of the supply is necessary from its source until it is delivered to the consumer.

Cross connection with polluted factory supplies installed for emergency purposes may cause pollution of a supply at any time. By a cross connection is meant a connection between the distribution system of a public or private potable water supply and a private or secondary non-potable water supply. Elimination of such connections is very desirable. Where such a procedure unduly increases the fire hazard, the minimum protection under the provisions of the state code must be in the form of an approved type of double gate and check valve installations, and regular monthly inspection by waterworks officials.

During January and February of 1929 a typhoid fever outbreak occurred in a Wisconsin municipality which was definitely traceable to a cross connection between the city supply and a polluted river supply used for industrial purposes. The epidemic resulted in 21 cases of typhoid fever with 6 deaths.

The connection permitting the discharge of contaminated water into the city mains was a 1½-inch service line which was installed in 1926 largely by employees of the industrial plant. According to information obtained from the owners of the plant and city water

superintendent the actual physical connections between the supplies was made at a later date by employes of the plant without notification to the water superintendent. The water obtained through this service line was used mainly for washing and refilling boilers, it being claimed that the city pressure was insufficient for general industrial use in the plant.

Inspection of the connection indicated that protection had been furnished by but a single gate valve set in a vertical position. Test of this valve under city pressure of about 40 pounds per square inch at the time of the inspection on February 27 showed leakage of as much as a pint in 15 minutes. The test furthermore showed that the valve would not seat equally at all times. If the valve could have been tested in place under factory pressure of 100 to 120 pounds working against the city pressure, a differential of 60 to 80 pounds, the leakage through the same valve settings would have been considerably more.

It is also possible that the valve was only partially closed after having been used to obtain city water. The plant engineer reports that the connection has been used on January 3 and February 9, and possibly at other times between the indicated dates.

The best indication that the river water passed through the valve and into the city distribution system is furnished by the condition of the meter on February 6 when it was examined by employees of the city water department. According to these men the meter screens were practically blocked by material deposited on them on the factory side, a knife being needed to remove the fibrous accumulation. A new disc was installed in the meter on February 19 and the screens replaced in clean condition. Examination of the meter on February 28, it having been removed the day previously, showed that some material had again accumulated on the factory side of the screens after having been in operation for only four days, namely from the 19th to the 22nd, when the connection was severed. This would tend to indicate that river water was being discharged into the mains up until the time the cross connection was eliminated.

That the typhoid fever epidemic was due to the cross connection is definitely indicated by the history and distribution of cases. The first case occurred on January 7 and was that of an employee of the industrial plant. This employee had been on a trip to Manitowoc and Chicago in the latter part of December. He may have contracted typhoid at some place on the trip or from carrier polluted

FIG. 1. TYPHOID FEVER EPIDEMIC CAUSED BY CROSS CONNECTED SUPPLY, TWO RIVERS, WISCONSIN: JANUARY–FEBRUARY, 1929. 21 CASES, 6 DEATHS

water at the industrial plant. This case, as well as some of the later cases, was of late diagnosis and the unsterilized excreta were discharged through city and industrial plant sewers into East Twin River from which the plant obtained its supply. One of the plant sewers is located within but a short distance, about 35 feet of the plant intake line. The first case seems to have been the direct cause of the epidemic, the cross connection acting as the distributor of the typhoid infected river water. The second case had its onset on January 23, and the third case on February 1, with the last on February 26.

The distribution of cases is in itself conclusive proof as to the source of infection, the history of cases being such that the city water was the only common source of infection both for employees of the plant and residents in the near vicinity. All of the cases among non-employees are located at such points along the city mains as would appear probable from the layout of the distribution system. Examination of figure 1 shows that water discharged into the city system at the point of connection with the industrial plant would would follow the 4-inch main west one block to the 6-inch main and thence north in said main and finally east into lateral mains. Drinking water for the industrial plant was taken from the 4-inch main at a point about 35 feet from the point of connection of the cross connected line, and thus employees in the plant would obtain the contaminated water before any of the persons not employed at the plant.

Milk, butter, cheese and other food products which might have spread such an infection were not of common use among the cases, and, furthermore, if some food product, or even city water infected at the pumping station or source, had been the cause, the cases would have been more widespread instead of being located in a small area. A history of cases shows the city water to be the only common source of infection.

Because of the numerous similar typhoid epidemics on record due to faulty cross connections, the State Board of Health regulations are not considered unreasonable. They provide:

"Any existing cross connection for fire protection purposes only which was originally installed before January, 1924, may be continued if protected by approved types of double check and gate valves equipped with suitable gauges and drains for testing, and on condition that monthly inspections of such equipment are made and reported upon by the owner of the public supply on

FIG. 1. TYPHOID FEVER EPIDEMIC CAUSED BY CROSS CONNECTED SUPPLY, TWO RIVERS, WISCONSIN; JANUARY-FEBRUARY, 1920. 21 CASES, 6 DEATHS

or before the tenth day of each month. The Board reserves the right to require elimination of any cross connection if inspections are not regularly made and reported upon, or if the connection is found faulty. All cross connections other than those used only for fire protection purposes shall be eliminated. New cross connections are prohibited. Permission to maintain any existing cross connection for fire protection purposes must be obtained from the Board on or before January 1, 1930."

The procedure for making and reporting the results of monthly tests of double check and gate valve installations is outlined in the code, copies of which may be obtained from the State Board of Health. The report blanks are also provided for the convenience of those making the tests and such repairs as found necessary. The degree of protection afforded water consumers against the danger of serious pollution from faulty cross connection depends largely on waterworks officials.

WATER FINANCING IN SMALL CITIES[1]

By Lawrence M. Bailey[2]

It has been my pleasure and privilege during the busy years to read a little of the worth while literature, and since I have been engaged in water department work, I have read several splendid stories and poems having to do with clear crystal springs, beautiful fountains and wonderful wells; and of how the seemingly ugly iron pipe and lead lines beneath our city streets were in reality the very arteries that supplied one of the necessities of life to the city. Nowhere in my reading did I find any mention of costs, bonds and sinking funds, but rather that water was God given—free for the taking.

You try to take some out of one of our hydrants without a permit.

Like most other things it must be paid for, and in a modern department this opens up a multitude of problems.

Undoubtedly, it is only in the last few years that in the smaller cities any attempt has been made to departmentalize, or to make any accounting of this important function of government.

In most of the smaller towns and cities, I am inclined to believe from my observations, that when any complete system of municipal accounts is in use the water department accounts are so grouped with other city accounts that little or no effort is made to segregate them and find just where the department stands.

It is difficult to suggest whether first to form a separate department and then develop an accounting system, or to do as we did in our city, develop an accounting system, and then departmentalize.

Probably most city charters, make it necessary that water funds be only a part of the general city funds, with these in the hands of the city treasurer. Nevertheless, these can be accounted for and treated as property of the department, and the activities carried on from the general city fund. I believe, however, a separate fund should be created.

In our city, the department is charged with all expenditures made in its favor, and credited with all revenue derived by it. General

[1] Presented before the Central States Section meeting, September 20,1929.

[2] City Controller, Lincoln Park, Mich.

items from stores of supplies and stocks, are charged to the department only when withdrawn from stores, and are then in effect the same as a cash expenditure.

New mains are installed by issuing thirty (30) year general obligation bonds. The interest on these bonds, and the sinking fund requirements are carried by the water department.

At the end of the year, the net result of operation, and this takes into consideration all activities of the department, interest on bonds and sinking funds, is carried to the general city budget as one item; either a profit, to help reduce general taxation, or as a loss, which will have to be raised by taxation.

A few of the things which I believe are more or less overlooked by the department in the smaller cities are as follows:

A. *Budget estimates in advance. Segregate water accounts. Depreciation and reserves*
   1. Adjusting profit or loss before carrying the net results of operation to budget.
   2. Reserves for replacement of mains.
      (a) Replacement by new bond issues.
      (b) Replacement by yearly charges.

B. *Unaccounted for loss of water*

C. *Water used by the municipality itself*
   1. Fire Department, Department Public Works, Sewer Department, Parks, etc.
   2. Establishing a yearly charge per hydrant.
   3. Water used by contractors.

WHAT IS ADEQUATE PRESSURE[1]

By R. S. Tait[2]

This subject is one of considerable importance to the water supply and requires much thought; for what might be an adequate pressure for one city would be just the opposite in another. It is difficult to determine the range of pressure that would be suitable for all systems, as naturally, pressure would vary in accordance with the local conditions.

Pressure is sometimes confused with volume. It is often said that no pressure is available, when as a matter of fact volume is what is needed. A tub placed on top of a mountain would give considerable pressure, but open up a fire plug and you would have no volume; again a river running through the center of a city may have plenty of volume, but without the proper appliances to discharge into the supply mains, it would have no value in pressure. Therefore, pressure and volume should work in harmony with each other.

There are different methods in vogue for supplying pressure to the distributing system and for fire protection. In many cities and towns direct hydrant pressure by gravity is widely employed, and if water pressure is sufficiently high considerable saving in time results. Others who are obliged to pump their supply from wells or rivers, find it a matter of economy to use a low head, and depend entirely on pumping engines for fire purposes. And there are still some who pump directly into the street mains, shutting off the reservoirs or standpipes in case of emergency, to build up pressure in case of fire. This, to my mind, is the least practical of any and should be discouraged. It may lead to disaster should a section of the supply main go out or the pumps fail at a time when most needed. In large cities hydrant pressure is not as common, but if the supply is by gravity and there is plenty of head, it can be used to good advantage.

In the City of Santa Cruz we have a pressure ranging from 90 to 100 pounds in the mercantile or the lower levels of the city; in the

[1] Presented before the California Section meeting, October 25, 1929.

[2] Superintendent, Water Works, Santa Cruz, Calif.

higher or residential sections from 65 to 75 pounds which we find very satisfactory for all ordinary purposes. We find it has its advantages in distributing an even pressure on the fire hydrants at all times. It enables the fire department to couple onto a hydrant and get water on a fire without delay. It has its advantages in installing smaller mains and services. It is useful in supplying an even pressure to the automatic sprinkler heads for fire purposes. It returns considerable revenue to the department in running freight elevators and hoists for the municipal wharf and other power purposes, and it is a joy and comfort to the property owners when they can by turning on a valve or valves, sprinkle the entire lawn or garden without much effort.

Therefore, it is my opinion that between 80 and 100 pounds is an adequate pressure to maintain for most cities for general use. Over 100 pounds is unnecessary or undesirable as it causes a greater expense in maintenance from leaky mains and services, and many complaints from house plumbing.

STATE SANITATION IN CALIFORNIA[1]

By Leon B. Reynolds[2]

The dictionary defines sanitation as the practical application of sanitary science through the removal or neutralization of elements injurious to health. Strictly speaking, the sanitary engineer is concerned with construction of works for promoting the health of the community. However, his field has been widening to include the abatement of nuisances as well as dangers to health. Community attractiveness from the standpoint of comfort and enjoyment is intermingled with community safety from the standpoint of health.

The efforts of the sanitarian have been chiefly directed toward the keeping of man's environment in a condition so that a minimum of disease would result from it. The main problem has been to keep man's food and drink from becoming contaminated, and thus frequently infected, by direct or indirect contact with his individual or community wastes.

The responsibility of the State of California toward its citizens, not only those grouped into cities, but all within its borders, was recognized by the passage in 1907 of the Sanitary Water Systems Act and the Public Health Act. The former was intended to promote the supply of pure, healthful water, and the latter was intended to promote the sanitary disposal of sewage. In 1915 the Legislature established the Bureau of Sanitary Engineering under the State Board of Health.

Biennial appropriations for the work of the Bureau since its inception have been as follows:

	dollars
1915–1917	30,000
1917–1919	45,000
1919–1921	50,000
1921–1923	68,770
1923–1925	38,350

[1] Presented before the California Section meeting, October 25, 1929.

[2] Professor of Hydraulic and Sanitary Engineering, Stanford University, Calif.

	dollars
1925–1927	49,063
1927–1929	52,204
1929–1931	57,050

Support of the Bureau was radically reduced six years ago from which it has not yet fully recovered. Population increase now seems to be the criterion for increased appropriation.

The actual personnel of the Bureau is no greater than it was fourteen years ago due to necessary increases in salary. In U. S. Public Health Bulletin No. 169 a rating of states as of July 1, 1927, is given, showing the population per state sanitary engineer; Delaware heads this list with 243,000 people per engineer, followed by Maryland, Rhode Island, Montana, New Mexico, Florida, New Hampshire, Arizona, Utah, Idaho, Connecticut, West Virginia, North Carolina, Maine, New York, Virginia, Oregon, Mississippi, Pennsylvania, Kansas, Wisconsin, Louisiana, Illinois, Colorado, Texas, Ohio, Michigan, Iowa, Tennessee, Alabama, Minnesota, Massachusetts, New Jersey, Arkansas, and (*thirty-fifth* in the list) California with 2,220,000 people per engineer. These detailed findings are shown in table 1. Five or six times as many engineers would be needed to put California in a class with Florida or even Arizona, New Mexico, or Montana. This is certainly not an enviable position for a state which should be known as a haven of health.

The last report of the Bureau covering the biennium July 1, 1926, to June 30, 1928, records 52 permits for sewage disposal, 12 permits for water supply and 63 for swimming pools. The helpful influence of the Bureau upon these projects is usually maintained from their conception to their completion.

The serious situation exists in the decreasing contact of the Bureau with the works after completion. The report reads as follows: "Of 63 water supplies depending upon disinfection, the average interval since they were visited by any one from the Bureau is 21.5 months; and of 13 supplies which were filtered, the average interval since latest visit is 10.5 months." A similar situation exists with reference to sewage disposal plants with intervals up to 29 months.

The status of sewage disposal became so serious that a California Sewage Works Association was formed one year ago with the object of interchange of information, experience and opinions among its members. The growth of this association to a membership of 210 in one year and the interest of the operators in the Association constitute a most hopeful sign that sewage disposal plants will soon become

TABLE 1

Rating of states in population per State Sanitary Engineer, as of July 1, 1927. From Public Health Bulletin No. 169

RATING	STATE	NUMBER OF STATE SANITARY ENGINEERS	POPULATION PER STATE SANITARY ENGINEER
1	Delaware	1	243,000
2	Maryland	6	266,000
3	Rhode Island	2	352,000
4	Montana	2	357,000
5	New Mexico	1	392,000
6	Florida	3	440,000
7	New Hampshire	1	455,000
8	Arizona	1	459,000
9	Utah	1	520,000
10	Idaho	1	534,000
11	Connecticut	3	540,000
12	West Virginia	3	560,000
13	North Carolina	4	720,000
14	Maine	1	793,000
15	New York (ex. of New York City)	7	800,000
16	Virginia	3	842,000
17	Oregon	1	890,000
18	Mississippi	2	895,000
19	Pennsylvania	11	900,000
20	Kansas	2	914,000
21	Wisconsin	3	970,000
22	Louisiana	2	1,000,000
23	Illinois (ex. Chicago)	4	1,040,000
24	Colorado	1	1,070,000
25	Texas	5	1,080,000
26	Ohio	6	1,120,000
27	Michigan	4	1,120,000
28	Iowa	2	1,200,000
29	Tennessee	2	1,242,000
30	Alabama	2	1,250,000
31	Minnesota	2	1,340,000
32	Massachusetts	3	1,410,000
33	New Jersey	2	1,870,000
34	Arkansas	1	2,000,000
35	*California*	2	2,220,000
36	Oklahoma	1	2,384,000
37	Kentucky	1	2,538,000
38	Indiana	3	3,150,000
39	Georgia	1	3,171,000
40	Missouri	1	3,500,000

places of increasing pride and efficiency. Research in the disposal of sewage and industrial wastes is urgently needed.

It is true that California's typhoid death rate for the last two years has been only 2.4 per 100,000, which is a creditable record. Since the serious typhoid epidemic in 1924 in South Pasadena and Santa Ana no waterborne outbreak of typhoid has occurred until the present year when there were two, neither of which was connected with a public water supply. Milk-borne and food-borne epidemics continue to occur with more or less regularity, showing the need of more adequate safeguards. Increasing sporadic cases of vacation typhoid indicate the need of supervision over recreational areas.

In the matter of laboratory analyses the Bureau may be said to have pioneered the way. The number of analyses now performed, however, by the Bureau is only one-tenth of the number ten years ago. Simultaneously many local laboratories have sprung up. For example, when the Bureau was organized, there were only two laboratories in Southern California making water and sewage analyses; now there are fifteen public and from five to ten private laboratories making such tests. Greater efficiency and reliablity would undoubtedly result if the Bureau had sufficient personnel to visit these laboratories at intervals to check their technique and interpretation.

During the past ten years the growth of sewage disposal has been so rapid that public demand has required an inequitable division of attention by the Bureau. It is estimated that 80 percent of its attention goes to sewage disposal problems, 15 percent to water problems, and 5 percent to swimming pools.

Several years have elapsed since a survey has been made of the water supplies employing chlorination. At that time the evidence seemed to be that on the average chlorination was about 50 percent reliable. In many cases only a single chlorination machine is in use; break-downs of single machines were responsible for the typhoid epidemic of 1918 in Merced Falls, 13 cases, and of 1920 in Pittsburg, 114 cases.

The American Water Works Association has taken a firm stand on the question of cross-connections with polluted supplies. The California Bureau has not enough personnel to make a survey of cross-connections and assist local authorities in campaigns for their elimination. The influence of the Bureau could be very useful to local departments in removing these potential dangers.

Several state boards of health in the East have been able after

investigation of water supplies to post signs along the highway indicating to motorists where the drinking water is safe. California is recognized as a great vacation state, attracting thousands of tourists, yearly, and such signs would make a good impression and reduce danger of disease. However, our great mileage of highways and numerous supplies would require a much greater staff of engineers in the Bureau to secure the trustworthy information upon which public confidence would be rested.

Purity of well waters in unsewered towns is also a phase of sanitary investigation which the Bureau has had insufficient personnel to attempt. The services of a sanitary engineer with laboratory facilities for analysis would be required.

Watershed sanitation is an important problem to which the Bureau has been unable to give much attention. The present method is to deputize the forest rangers in our national forests as state sanitary inspectors and then give them no supervision whatever. In some instances due to lack of knowledge they have acted in conflict with county inspectors. Recently thousands of chemical toilets have been installed on these watersheds, thus bringing up new questions regarding their installation and the disposal of their contents. Watershed sanitation needs more supervision.

In a number of cases in Southern California important water supplies have been destroyed by salting up of underground waters due to discharge of oil wastes into surface streams or due to interconnections of strata in oil wells. Already three salt water pipe lines have been built and others are proposed to prevent this destruction of well water supplies.

The chemical constituents of our water supplies, while possibly unimportant as regards health, are nevertheless deserving of attention. It is true that we have many supplies of relatively soft water from mountain sources, but we also have some hard waters from underground sources. Increasing dissatisfaction is manifested regarding hardness, iron and manganese in our waters. Beverly Hills has a softening and hydrogen sulphide removal plant and other cities are considering the removal of those undesirable chemicals. The Bureau is being called upon for advice and should have time and personnel to assist.

Permits for swimming pools must be obtained from the Bureau and there are at least 550 pools in the state at present. Permits are granted when the design and equipment give promise of good sanitary

conditions, but unfortunately little attention can be paid to their operation afterward. The protection of bathing beaches is also a matter of concern to the Bureau, and those natural assets should be preserved in a safe condition for use by our citizens and visitors.

General knowledge of sanitation is increasing and responsibility for health conditions is being more willingly and intelligently assumed by local authorities. To a considerable extent this assumption of responsibility may be welcomed, but the helpful influence of a state agency cannot be ignored. Frequent contacts of local with state sanitarians should be informative and stimulative and productive of better results. Responsibility does and should rest with local health authorities, but encouragement and helpful advice may well come from the State Board.

Our Bureau has been instrumental in creating an appreciation of sanitation and has used persuasive rather than dictatorial methods. The report of the Bureau for the last biennium indicates over 2100 inspections and 3200 conferences, a wonderful record in view of the limited personnel, and from it may be inferred the greatly increased service which it could render with adequate personnel. In order that it might occupy its true position, which is useful service to the citizens of the State in matters pertaining to health, it should be given increased personnel of sanitary engineers, laboratory technicians and necessary clerical force.

The California Sewage Works Association two weeks ago unanimously passed a resolution recognizing the importance of adequate supervision by the Bureau of Sanitary Engineering of the State Department of Health in order that efficient operation of sewage treatment and water purification plants might be secured, recognizing the present inadequacy of support and personnel, and authorizing representatives of the Association to confer with the Governor and Director of Finance and urge sufficient future appropriations to allow needed additions to personnel of the Bureau. As some one recently expressed it, the Bureau is attempting a "Herculean task with a pitiably small staff."

The California Section of the A. W. W. A. might, it seems to me, very sensibly take similar action by resolution and join its influence with that of the Sewage Works Association in an effort to improve the quality of sanitation in this state.

Erwin Eugene Lanpher

Died January 18, 1930

Erwin Eugene Lanpher was born January 28, 1875, in Lowville, N. Y. He was the son of A. Marcellus Lanpher, real estate broker, and postmaster of Lowville.

His early education was at Lowville Academy, after which he graduated from Union College, Schenectady, N. Y. He graduated from Cornell University on June 22, 1899, with the degree of Civil Engineer.

During 1899 and 1900, he was with the Department of State, in Nicaragua, on a survey of the proposed Central Nicaragua Canal, under General Goethals. At the finish of the field work, Mr. Lanpher resigned, and returned to the United States.

From 1900 to November 15, 1904, Mr. Lanpher was Assistant Engineer, Water Department, Atlantic City, New Jersey, being associated with Mr. W. C. Hawley.

On November 15, 1904, he became Assistant Engineer, Bureau of Water, City of Pittsburgh, Pa. On May 5, 1913, he became Division Superintendent, in charge of the Distribution Division. On June 1, 1926, he was appointed to the position of Managing Engineer, Bureau of Water, City of Pittsburgh, which position he held until the time of his death. He was in active discharge of his duties until the hour he died by a heart attack.

In April, 1905, he married Miss Helen Moore, of Atlantic City, a graduate of Swarthmore College.

Mr. Lanpher wrote "A Century of Pittsburgh Water Works," which he presented before the Engineers' Society of Western Pennsylvania, in May, 1928. He also wrote "A Description of the Pittsburgh Water Works, Prepared to Meet the Requirements of the Students of the Schools of Pittsburgh," on February 1, 1929.

Beside his active participation in the construction of the various

pipe lines necessary for the distribution system, he was in charge of the construction of the North Side Reservoir, Pittsburgh.

Later, as Managing Engineer, he was largely responsible for the design and construction of McNaugher Reservoir, completed in 1928, and Brashear Reservoir, completed in February, 1929.

He devoted a great deal of attention to important reconstruction in Ross Pumping Station, and was engaged in the study of rebuilding Brilliant Pumping Station, at the time of his death.

Mr. Lanpher held a certificate of registration as a Professional Engineer, in Pennsylvania.

He became a member of the American Water Works Association on April 8, 1922. He was chariman of the Civil Section, Engineers' Society of Western Pennsylvania. He was a member of the Chamber of Commerce, Pittsburgh, the Junta Club and the Cornell Club of Pittsburgh. He was a member of Sojourners' Lodge No. 693, and Bellefield Chapter No. 299, F. & A. M., and of Tancred Commandery No. 48, Knights Templar.

He is survived by his wife, a sister, and a brother.

His was a life of devotion to his work. Pittsburgh has lost an efficient man who gave twenty-six years of his life to an important branch of public works. Few pass out of public life, possessed of greater devotion and respect of his fellow-men.

C. F. DRAKE.

DISCUSSION

The Washing of Rapid Filters

The extensive and interesting discussion which this paper[1] has elicited has been very gratifying to the writers. Although the data and interpretation seem to have met with quite general acceptance, a brief reply to a few of the points raised in the discussion may serve to make our contentions quite clear. In what follows an attempt has been made to do this.

An important question was raised by Mr. Baylis, and one or two others of those commenting, as to whether the use of very high washing rates could be expected to prove a universal panacea for filter sand ailments. In Detroit the experimental work has demonstrated, without much doubt, that a high expansion wash is the solution of filter sand troubles. However, it is quite possible that many other plants using only the customary 24-inch, or thereabouts, rate of wash, may obtain, during at least part of the year, the 45 to 50 percent sand expansion that we found necessary here. Others may not. But where sand bed troubles are experienced, and we believe that conditions similar to those we have described are widespread, some attention may be given profitably to regulating the filter wash in order to obtain a constant, and if possible, a higher degree of sand expansion the year around.

Being convinced, as we are, that the degree of sand expansion is the true indicator of the intensity of the filter backwash, and not the velocity of wash water rise, we would be the last to suggest any definite rate of filter wash as suitable for general application. The rate of wash required to obtain, say a uniform 50 percent sand expansion, will undoubtedly be different for various filter plants. If it were desirable to standardize upon a certain intensity of wash to produce efficient filter cleaning wherever used, no fixed velocity of wash could be recommended, since the expansion will vary, (1) with the temperature or viscosity of the wash water, (2) with the size characteristics of the sand composing the filter, and (3) with the

[1] Journal, November, 1929, page 1445.

specific gravity or relative weight of the sand. As a concrete illustration of this, we give below a table of interpolated results for a filter washed at the customary 24 inches per minute velocity, where sand characteristics, water temperature, and depth of sand are variable. The figures are calculated from experimental data available here.

VELOCITY OF WASH	DEPTH OF SAND	30 PERCENT SIZE OF SAND	SPECIFIC GRAVITY OF SAND	WATER TEMPERATURE	SAND EXPANSION	
inches per minute	*inches*	*mm.*		*°F.*	*inches*	*percent*
24	30	0.55	2.55	70	3.9	13
24	30	0.55	2.55	33	7.2	24
24	30	0.55	2.65	33	6.0	20
24	30	0.45	2.65	70	15.0	50
24	20	0.45	2.65	70	10.0	50

These data make it apparent to what extent washing results may differ when the customary 24 inches per minute velocity wash is applied to filters that are not alike in sand characteristics, or even when used on the same filter at different wash water temperatures.

The sand in the Detroit experimental filters accumulated a large amount of coating during the time they were washed at rates less than 30 inches per minute. Once clean, however, it was learned that washing at higher velocities prevented the sand from again becoming coated. We assume that the significant effect of the higher washing rate was to expand the sand bed to a greater degree during the backwash. Even though it should prove to be true, as Mr. Baylis says, that sand "just in a state of motion has almost as much scrubbing effect as if the backwash was much greater," the entrained coagulum will be driven out of a dirty filter more freely, rapidly and completely when the sand layer is opened up or expanded to a greater degree than is usual.

Again, Mr. Baylis in his remarks states his unreadiness to recommend rates greatly in excess of the customary 24 inches per minute on account of the possible danger of disturbing the fine gravel. We have noted in our experiments that washing rates as high as 60 inches per minute had no tendency to lift gravel as small as 2 to 3 mm. in diameter.

Mr. Kiersted raises the question of the depth of penetration of floc into the filter bed. This depth is, in all probability, quite variable, depending upon the character of the floc reaching the filter, the

rate of filtration, and the size of the sand composing the bed. Slow, but deep, penetration seems desirable, as it probably makes for longer filter service. Detroit's filters contain 30 inches of coarse, not very uniform sand. In these beds, by far the greater portion of the floc lodges in the top six inches of sand, and once passing this stratum, goes through the deeper layers rather freely. One filter here containing only 20 inches of a fine, uniformly graded sand gives excellent results. It appears to filter as well as, if not better than the others, washes easily, and loses head only slightly more rapidly than do the others. It seems to us quite probable that shallower sand beds, composed of more uniform sand than generally used would give equally as good results.

Wash water troughs should be so placed as to allow clearance between the bottom of the troughs and the sand surface when the bed is expanded during the wash. If the sand surface is raised above the trough invert during the wash, as often happens, much of the fine top sand may be washed out, due to the higher velocity prevailing between the troughs.

A certain amount of film, or coating, on filter sand may ordinarily be desirable, as suggested by Mr. Jordan. In the experimental filters, what has been called "clean sand" had on it an average of about 0.5 percent coating substance, too small an amount to be visible. Although this sand was quite coarse, and had on it only this slight grain film, it gave excellent results in the filter.

The reference to 4 percent wash water consumption at the experimental plant was unfortunate, as it proved misleading to several of those commenting upon the paper. The 4 percent estimate as given, was based upon a filter run of six hours length, and a washing period of one and one-half minutes. The filter runs had been limited to six hours because of the desirability of operating at times without any sedimentation, and in order to complete one experimental run during each operating shift. It is obvious that the percentage of wash water is dependent upon the amount of water delivered by the filter, just as much as it is upon the amount of wash water used. Most of the time the filters could have been kept in operation two or three times as long as they were, and the wash water consumption thereby reduced to 2 or $1\frac{1}{3}$ percent. Mr. Lawrence at Cleveland has reported a very considerable saving in wash water by using a year around sand expansion of 50 percent in washing, and a similar

saving at higher wash rates has been reported by Mr. Hopkins at Baltimore.

In order to keep mud banks from forming and growing on top of the gravel along the filter walls, the writers have also resorted to the use of long handled rakes during the wash, as mentioned by Mr. Mansfield. Apparently this condition is brought about by lack of strainers, or manifold outlets close to the filter walls. Where such trouble exists, a more intense wash, that is, a higher expansion wash, appears to prevent it from becoming aggravated, but does not cure it completely, for, regardless of the velocity of the wash, the upward flow of water through the sand close to the walls is restricted, or entirely cut off in those places where mud banks have formed. After removing this mud, a little exploring with the rakes during the wash reveals the fact that the sand is idle in those places, that is not lifted or expanded, because of lack of water flow. Quite naturally mud will accumulate there.

Experience in Detroit with filter sand maintenance troubles has evidently been different from that reported by Messrs. Wolman and Powell. Seventy-six of Detroit's eighty filters contain a rather coarse, not very uniform sand, thirty inches in depth. Nearly all of these have given trouble with shrinkage, coating and mud formations. The other four filters are equipped with four different sands, three of which are considerably finer and more uniform in grading than the regular sand. These latter three sands have never, during the five years they have been in use, shown any tendency toward shrinkage or cracking. The fourth filter, which contains the coarsest of all those in the plant, does not show wall cracks or shrinkage either, but this sand has become coated to such an extent that its surface is now eight inches above the original level. This fact indicates, to our mind, that the available rate of wash of about 28 inches per minute is too low for such a coarse sand.

In general, here, sand shrinkage is most evident in those filters located the greatest distance from the source of wash water supply, perhaps because the increased loss of head through additional piping results in less wash water pressure at the filter, and consequently less expansion of the sand during the wash.

ROBERTS HULBERT[2] AND FRANK W. HERRING.[2]

[2] Detroit, Michigan.

A Note on Hydrogen Ion Concentration

In the paper on "Some Water Works Corrosion Problems" by Ira D. Van Giesen in the January, 1930, number of THE JOURNAL the following amazing statement is made: "The one great difference observed was in the soil which ranged from a pH value of 4.3 to 8, i.e., an acidity equivalent to a 43 percent solution of hydrochloric acid to an alkalinity of a 33 percent solution of sodium hydroxide." The fallacy of this statement becomes obvious when one realizes that the concentrated hydrochloric acid on the market contains between 37 and 38 per cent hydrogen chloride and represents practically the limit of the solubility of hydrogen chloride in water at ordinary temperatures and pressures. Certainly the acidity of the soil in question was not of this order of magnitude. Further, a pH value of 8 is within the range of ordinary potable waters, which surely do not have an alkalinity comparable to that of a 33 percent solution of sodium hydroxide.

It might, therefore, perhaps be well to append here a fundamental relation useful in converting pH values to actual concentrations.

As is well known, hydrogen ion concentrations are stated in terms of pH only for convenience, e.g., the hydrogen ion concentration of water is 10^{-7} gram ions ofhydrogen per liter while the pH is the much simpler value, 7.0. The relation of the two terms is then expressed by the equation

$$\text{pH} = \log \frac{1}{C_{H^+}} = -\log C_{H^+},$$

where C_{H^+} is the concentration of hydrogen ion in gram ions per liter, and the logarithm is taken to the base 10.

Then $C_{H^+} = \text{antilog} \frac{1}{\text{pH}} = -\text{antilog pH}$

If we let $x \cdot y$ represent the pH value of a solution, then x is the characteristic of a logarithm and y is the mantissa. The expression for C_{H^+} then becomes

$$C_{H^+} = \text{antilog}\,(1-y) \times 10^{-(x+1)}$$

For example, for a pH value of 4.3, x = 4 and y = 0.3. C_{H^+} then is antilog $(1-0.3) \times 10^{-(4+1)}$

$= \text{antilog } 0.7 \times 10^{-5}$

$= 5.012 \times 10^{-5}$, or approximately 0.00005 gram moles or 0.0018 grams of HCl per liter. This value of 0.00018 percent is certainly far from 43 percent HCl.

Similarly a pH value of 8.0 corresponds to a hydrogen ion concentration of 10^{-8} gram moles per liter, or a hydroxyl ion concentration of 10^{-6} gram moles per liter, since the product of simultaneous values of C_{H^+} and C_{OH^-} must be 10^{-14}.

Since 10^{-6} = 0.000001 gram moles or 0.00004 gram of sodium hydroxide per liter, the concentration is not 33 percent but 0.000004 percent.

SELMA GOTTLIEB.[3]

LACTOSE BROTH FERMENTERS[4]

The article by Spray and Laux entitled "A Peculiar Lactose-Fermenting Anaerobe from Filtered and Chlorinated Water" presents a problem that is fairly common in plants dealing with raw waters of aged or remote pollution. No previous reference has been made to such occurrences in freshly polluted water. The problem was doubtless the basis of the "B. welchii" discussion originated by Larner at Montclair (1). It was also commented upon by Calvert (2). Leitch (3) studied the matter and confirmed the conclusions of Sears and Putnam (4) that it is the result of bacteriological activity known variously as commensalism, symbiosis or synergism—i.e., the growth of two organisms in a common environment whose metabolic activities produce a result erroneously interpreted as the effect of growth of a single organism (generally not isolated). Leitch concluded that the disturbing factors in the presumptive test for B. coli are the result of activity of (A) an acid forming, gram positive, non-motile, non-sporing organism having the ability to break down lactose to simpler structure and (B) a gram-negative, non-sporing, motile organism having the power to produce acid and gas from glucose and maltose. The first organism acts as a simplifier of the lactose to the point that the product can be used as a source of gas production by the second.

The writer furnished a series of references (5) in an attempt to correlate previous studies along this line. The work of Stearn and Stearn (6) shows why gram positive organisms are generally unable to grow in media containing dyes. The various investigations on dyes of the tri-phenyl-methane series both with and without combination with bile have shown the value of such added materials in

[3] Lawrence, Kans.

[4] Journal, February, 1930, page 235.

plant control laboratory work. Spray and Laux would add to the value of the information they now have if their further studies made use of the method suggested by the writer in THIS JOURNAL (7) and modified as follows:

Classify the results of parallel tube inoculation into three groups.

Group 1. Both tubes gas positive in 24 hours.

Group 2. Both tubes gas positive in 48 hours.

Group 3. Lactose broth tube positive in 48 hours. Original brilliant green tube negative in 48 hours but growth occurring upon reinoculation from the fermented lactose tube.

The significance of these groups—as judged by the work of the coöperators on the original study as well as continuous use of the method in this laboratory since 1927 is as follows:

Group 1 organisms are active coli. They are practically never found in a water adequately prepared for distribution and, if found, imperatively indicate a prompt review of all operating conditions.

Group 2 organisms represent significant pollution somewhat removed.

Group 3 organisms are of the aged or attenuated type found in stored waters.

The organisms found by Raab, Calvert, Leitch and Spray and Laux will not grow even as Group 3 organisms, because the dye environment has been found uniformly to exclude the gram-positive group of acid formers.

This much is positive if experience has any value. The delayed fermentation results in lactose broth studied by Spray and Laux do not indicate the presence of the Coli-aerogenes group, nor do they represent B. Welchii. There is no evidence that they represent any type of organisms that have sanitary significance, but simply a rugged saprophytic group resistant to ordinary purification methods that find in the conventional lactose broth tube a locale for combining their various metabolic activities. It may be suggested that waters containing such organisms respond well to pre as well as post chlorination and if both dosages are adjusted on a definite "excess" basis, such laboratory results will largely disappear.

REFERENCES

(1) Engineering News Record, vol. 87, p. 929.
(2) Jour. Amer. W. W. A., vol. 11, p. 307.
(3) Jour. Amer. W. W. A., vol. 13, p. 186.

(4) Journal Infectious Diseases, vol. 32, p. 270.
(5) Jour. Amer. W. W. A., vol. 14, p. 546.
(6) Journal Bacteriology, vol. 8, p. 567.
(7) Jour. Amer. W. W. A. vol. 18, p. 345, Paragraph 4, vol. 21, p. 670.

HARRY E. JORDAN.[5]

THE DETERMINATION OF BIOCHEMICAL OXYGEN DEMAND

Dr. Mohlman has called attention to an error in the part of the report of Committee No. 1 which pertains to his assignment on biochemical oxygen demand. The error is in the second paragraph on page 252 of the February issue of THE JOURNAL (Volume 22, Number 2). The incorrect sentence reads as follows: "Investigations of synthetic diluting waters are being made in a number of laboratories. Some of the simpler of these synthetic waters contain 60 p.p.m. potassium bicarbonate (Sanitary District of Chicago)." This sentence should read as follows: "Some of the simpler of these synthetic waters contain 60 p.p.m. potassium bicarbonate (New Jersey State Department of Health) and 300 p.p.m. sodium bicarbonate (Sanitary District of Chicago)."

On account of Dr. Mohlman's absence from Chicago his material was not included in the first two revisions of the report of Committee No. 1. It was received in time for inclusion in the final draft of the report. This report was sent out for final checking and apparently was not noticed as incorrect.

JACK J. HINMAN, JR.[6]

[5] Indianapolis, Ind.
[6] Chairman, Committee No. 1, Iowa City, Ia.

SOCIETY AFFAIRS

THE KENTUCKY-TENNESSEE SECTION

The fifth annual meeting of the Kentucky-Tennessee Section was held at the LaFayette Hotel, Lexington, Ky., on January 23, 24, and 25, 1930.

The meeting was called to order at 10 a.m. by W. H. Lovejoy, Chairman. Address of Welcome was given by David C. Hunter, of the City Corporation Counsel in the absence of Mayor Jas. J. O'Brien, who was out of the city. Response was given by A. F. Porzelius, Superintendent of the City Water Company, Chattanooga, Tenn. Secretary B. C. Little, of Rochester, N. Y., brought news of various matters which were being considered by the parent association. After the appointment of committees the meeting adjourned until the afternoon session.

At the afternoon session papers entitled "An Understanding Public," W. C. Stair, District Manager, Kentucky Utilities Co., Middlesboro; "Design and Construction of Additional Filter Units," A. T. Clark, Chief Engineer, Community Water Service Co., New York and Hugh Cramer, Chief Engineer, Lexington Water Co., Lexington, Ky.; "Benefits derived from Prechlorination," J. J. Quinn, Chief Chemist, Knoxville Water Co., Knoxville, Tenn., "Minor Details of Construction and Features of Operation of Municipal Water Works Systems from the Public Fire Prevention Standpoint," Clarence Goldsmith, Assistant Chief Engineer, National Board of Fire Underwriters, were read and discussed.

The Nomination Committee reported the nomination of A. E. Clark, Associate Sanitary Engineer, State Department of Health, Nashville, Tenn., as Chairman; Howard K. Bell, Consulting Engineer, Lexington, Ky., Vice-Chairman; Felix Vannoy, Superintendent, Municipal Water and Light Co., Madisonville, Ky., James Sheahan, General Superintendent, Water Commission, Memphis, Tenn., Directors, and A. F. Porzelius, Manager, City Water Company, Chattanooga, Tenn., was unanimously elected as section trustee to the American Water Works Association.

The meeting then adjourned until the evening when a smoker was held in Dicker Hall, University of Kentucky. At this smoker the motion picture "Cast Iron Pipe—Its Relation to Health, Safety and Public Welfare" was shown.

On Friday morning the session was devoted to the reading of the following papers: "The Development of the Design and Operation of the Modern Filtration Plant," C. B. Burdick, of Alvord, Burdick and Howson, Consulting Engineers, Chicago, Ill., "Good Will and Its Importance," J. C. McClendon, General Manager, Union Water Co., Lexington, Ky., "Principals of Chlorination," J. N. Jernigan, Wallace & Tiernan Co., Lexington, Ky. The paper "Characteristics of Deep Well Waters in Tennessee" by W. F. Pond, State Geologist, was read by Roy J. Morton.

At the afternoon session the following papers were read: "Simplified Method of Detection of Gas Formers and Their Significance in the Bacteriological Examination of Water," Dr. William Litterer, State Bacteriologist, Nashville, Tenn.; "New Water Filtration Plant at Bowling Green, Ky.," D. E. Davis of The J. N. Chester Engineers, Pittsburgh, Pa.; "Water Supply and Its Relation to Disease," Dr. J. L. Jones, State Epidemiologist, Louisville, Ky.

At 6:30 those attending were entertained at dinner in the Gold Room of the LaFayette Hotel by the Lexington Water Co., and The Union Water Co., Lexington, Ky. F. C. Dugan presided and talks were given by the Hon. James J. O'Brien, Mayor of the City of Lexington, W. S. Cramer, Vice-President of the Lexington Water Works Co., and F. Paul Anderson, Dean of Engineering, University of Kentucky.

The session Saturday morning was devoted to "Algae and Its Control," E. E. Jacobson, Field Engineer, Union Water Co., Lexington, Ky., and "Purification Plant of the Lexington Water Co.," Martin Flentje, Superintendent of Purification, Community Water Service Co., New York; Clark Cramer, Station Engineer, Lexington Water Works Co., Lexington, Ky.

A. E. Clark, the new Chairman, announced that F. C. Dugan, Chief Engineer, State Board of Health had been re-elected Secretary-Treasurer for the coming year.

The meeting then adjourned to be the guests of the Lexington Water Company at their plant where a fish fry was held and an inspection made of the plant.

F. C. DUGAN,
Secretary-Treasurer.

THE ROCKY MOUNTAIN SECTION

Meeting in Denver on the 13th and 14th of February, 1930, for its fourth annual meeting, the Rocky Mountain Section discussed many problems of water works interest. An attendance of over 100 water works officials from within and without the Section's territory indicated the growing interest in these conventions. Among those coming from the far corners of the territory were the city water superintendents from Artesia, New Mexico; Evanston, Gillette and Sheridan, Wyoming; whereas some water works men came from Provo, Utah; Kansas City, Mo.; Chicago and Boston.

The election of officers resulted as follows:

Chairman: L. C. Osborn, City Engineer, Loveland, Colo.

Vice-Chairman: G. C. Culberson, Manager, Water Works, Raton, N. M.

Secretary-Treasurer: Dana E. Kepner, District Manager, Pacific States Cast Iron Pipe Co., Denver, Colo.

Directors (three-year terms): Frank E. Keenan, Water Superintendent, Gunnison, Colo.; Chester Truman, Superintendent, Northfield Water Co., Colorado Springs.

National Director, to represent the Rocky Mountain Section on the Board of Directors of the American Water Works Association, D. P. Porter, Superintendent, North Side Water Works, Pueblo, Colo.

At the opening session, the morning of the 13th, papers were presented on corrosion and conservation of underground structures, stressing the importance of using water pipes not subject to rapid rusting, and water accounts and the public, mentioning the necessity of having city water department financing, billing and collecting on a sound business basis. Lengthy discussions followed each of the papers bringing out many angles of the subjects involved and answering many questions in the minds of the men in attendance.

The afternoon session on the 13th began with a paper on recent developments in safeguarding cross-connections, bringing out approved methods of preventing the spread of water-borne disease in connection with the use of impure water supplies for industrial purposes and fire protection. Following this paper were two inspection trips during which were demonstrated the manufacture of lead pipe by the Wensley Metal Products Company and the operation of the Capitol Hill pumping station of the Denver water works, transportation to both being provided by the Denver Board of Water Commissioners.

Industrial motion pictures were shown during the evening of the first day, depicting the manufacture and testing of McWane-Pacific Cast Iron Pipe, National Tube seamless steel pipe, Lock Joint concrete pipe, various trenching and backfilling machines, Dorr water treatment equipment, and General Electric pipe welding processes. A smoker and elaborate Dutch lunch ended the opening day.

The program for the second day opened with a brief but clear description of the new sewage treatment plant of the separate sludge digestion type at Aurora, Colo., preparatory to the inspection trip scheduled to this plant through the courtesy of the Dorr Company the following morning. The subject of iron removal from water was then presented and a description given of the Albuquerque, New Mexico, iron removal plant. Omitted inadvertently from the printed program, but of great interest to those in attendance, was a paper presented by Ben Davis, Water Superintendent, Rawlins, Wyoming, describing the repairing of wood stave pipe with patches of sheet lead covered with smaller, properly curved steel plates, all held on by a new band and the protruding lead calked under the edges of the steel plate. The patching was demonstrated on a full size section of 16-inch wood stave pipe. An exhaustive recitation of the history of the controversy between Colorado and Kansas concerning the use of water from the Arkansas River, and an informal discussion of problems confronting a watershed patrolman, completed this session.

During a luncheon meeting at noon on the 14th the election of officers was held and general Section business was transacted, followed by a particularly scholarly presentation of the notable aims and creditable accomplishments of the American Water Works Association since its beginning, by its President, Mr. Jack J. Himan of Iowa City, Ia.

Legal phases of municipal water storage, presented by a competent water works attorney, and the treatment of a tropical water supply by President Hinman, were the only papers on the afternoon program of the 14th. Following these papers, however, were round table discussions on water meter setting, water works plant beautification, beneficial water use promotion, activated carbon filtration, and miscellaneous water works subjects.

A banquet followed by music and dancing skits concluded the convention. Funds for the entertainment, smoker and Dutch lunch were obtained through nominal registration fees paid by non-members.

DANA E. KEPNER,
Secretary-Treasurer.

ABSTRACTS OF WATER WORKS LITERATURE[1]

FRANK HANNAN

Key: American Journal of Public Health, 12: 1, 16, January, 1922. The figure 12 refers to the volume, 1 to the number of the issue, and 16 to the page of the Journal.

Paints for Metal. Iron, Steel, Copper, Galvanized, Tinned, and Other Metal Surfaces. H. A. GARDNER. Am. Paint Varnish Manufrs. Assocn. Circ. 331: 509–68, 1928. From Chem. Abst., 22: 3539, September 20, 1928. Relative degrees of usefulness of various pigments for metal protective paints are presented. Methods of painting various types of metals are given, and results of some recent tests are illustrated with photomicrographs. Brief history given of some important paint tests made in America.—*R. E. Thompson.*

Sixty-Fourth Annual Report on Alkali, etc., Works in England and Wales in 1927. T. LEWIS BAILEY. Ann. Rept. Alkali Works, 1928, 3–35. From Chem. Abst., 22: 3713, October 10, 1928. Methods of analysis given for ammoniacal and spent liquors, together with notes on estimation of polyhydric phenols.—*R. E. Thompson.*

Bureau of Standards Soil-Corrosion Studies. I. Soils, Materials and Results of Early Observations. K. H. LOGAN, S. P. EWING and C. D. YEOMANS. Bur. of Standards Tech. Papers 1928, 368: 447–554. From Chem. Absts., 22: 3619, October 10, 1928. Test pieces of various metals and coated metals were buried in soils of different compositions. Examinations of specimens removed after 1, 2 and 4 years permit no definite conclusions to be drawn regarding corrodibility of different metals of similar groups. Work thus far shows that type of corrosion of a group is influenced by nature of soil. Most soils are but slightly corrosive. In many cases corrosion rate and pitting rate fall off with time. Galvanized pipes are in general more resistant to corrosion than untreated pipe. Corrosiveness decreases with increasing weight of zinc coating. Some soils corrosive to steel cause formation of protective film on zinc which affords good protection. Thin bituminous coatings yield insufficient protection against severely corrosive soils, probably because of poor methods available for application. Lead and zinc fail by pitting in some soils and aluminum is rapidly attacked. Copper and high-copper alloys are generally resistant in

[1] Vacancies on the abstracting staff occur from time to time. Members desirous of coöperating in this work are earnestly requested to communicate with the chief abstractor, Frank Hannan, 285 Willow Avneue, Toronto 8, Ontario, Canada.

all soils. Investigation has not proceeded sufficiently far to warrant definite conclusions to be drawn regarding relative merits of metals of same type.—*R. E. Thompson.*

Experimental Studies on Combined Indole and Fermentation Methods for the Identification of Colon Bacilli in Drinking Water. I. E. MINKEVICH. Centr. Bakt. Parasitenk. II Abt., **73**: 338–46, 1928. From Chem. Abst., **22**: 3716, October 10, 1928. Most satisfactory fermentation medium is that of BULIR. It is tryptophan made by treating peptone for 3 days with pancreatic extract, plus 1 per cent mannitol. Indole test by method of GERSBACH is useful supplement, i.e., reddish violet color with chlorine water. Glucose inhibits indole formation. Maltose is unsatisfactory, as is also a 46° incubation temperature. Calcium carbonate has no effect on rate of indole formation.—*R. E. Thompson.*

The Effect of Chlorination on Drinking Water. The Use of α-naphthoflavone as Indicator for Free Chlorine. M. HAHN, F. SCHÜTZ and SPIRO PAVLIDÉS. Z. Hyg. Infektionskrankh., **108**: 439–73, 1928. From Chem. Abst., **22**: 3716, October 10, 1928. Relationship exists between oxidizability of given sample of water and necessary amount of chlorine for destruction of bacteria present. By titrating chlorinated water with α-naphthoflavone as indicator the point where excess of chlorine is present can be easily determined and thus a sufficiency maintained.—*R. E. Thompson.*

Principles of Chlorine Sterilization of Drinking Water. G. LUTZ. Z. Hyg. Infektionskrankh., **107**: 585–91, 1927. From Chem. Abst., **22**: 3716, October 10, 1928. Disinfecting action of chlorine is a chlorine effect. In first few hours after chlorination the chlorine decreases only slightly, and amount of oxygen formed is small; yet notable decrease in number of added bacteria occurs.—*R. E. Thompson.*

Use of Liquified Gases for the Disinfection and Eradication of Infesting Insects. H. PICK. Chem. obzor, **3**: 8–11, 40–1, 73–9, 1928. From Chem. Abst., **22**: 3716, October 10, 1928. Use of chlorine for sterilizing water discussed.—*R. E. Thompson.*

Purifying Water. RALPH B. DERR (to National Aluminate Corporation). U. S. 1,680,506, August 14. From Chem. Abst., **22**: 3718, October 10, 1928. Water containing less than about 50 p.p.m. magnesium sulfate is mixed with water softening compound such as lime and soda ash and sodium aluminate and formation of a coagulant is activated by adding magnesium sulfate or other material supplying magnesium and sulfate ions.—*R. E. Thompson.*

Treatment by Chlorination of Lunéville Water Supply. M. P. VINET. Tech. Sanit. Municip., **23**: 128–31, 1928. From Chem. Abst., **22**: 3940, October 20, 1928. Description of installation and operation.—*R. E. Thompson.*

Corrosion in Gas Technic. CL. G. DRIESSEN. Het Gas, **48**: 271–80, 1928. From Chem. Abst., **22**: 3977, October 20, 1928. By coating experiments with agar-potassium ferricyanide-phenolphthalein (ferroxyl reagent) presence of local elements on iron surface can be shown by blue or red coloration. Occurrence of this important factor for corrosion was found in decreasing order on cast iron, wrought iron, steel, stainless steel, Monel metal; last one being altogether free. Suggested that ferroxyl reaction be used for regular testing of material. Theories of corrosion are reviewed and numerous references given.—*R. E. Thompson.*

Determination of Halogens in Water from Petroleum Beds. P. PETRESCU. Bul. soc. chim. Roumania, **10**: 26–8, 1928. From Chem. Abst., **22**: 3981, October 20, 1928. Determination of iodine is difficult, as it is reabsorbed as soon as liberated because of organic matter. Satisfactory method is based on reaction: $H_2O_2 + 2HI \rightarrow I_2 + 2H_2O$. Sample is acidified with 0.5 cc. dilute hydrochloric acid and treated with 1 to 3 drops of perhydrol or 1.5 cc. hydrogen peroxide. Agitate strongly with carbon bisulfide several times during 30 minutes and titrate with thiosulfate. Concording results are obtained even 48 hours after liberation of iodine. Bromine is not liberated by this method.—*R. E. Thompson.*

Notes on Recent Developments in Fuel Technology. R. WIGGINGTON. Fuel in Science & Practice, **7**: 241–4, 287–9, 333–5, 1928. From Chem. Abst., **22**: 3974, October 20, 1928. Brief reviews of, among other subjects, removal of oxygen from feed water and water softening with barium salts.—*R. E. Thompson.*

Spontaneous Heating of Coal. JOSEPH D. DAVIS and D. A. REYNOLDS. Bur. Mines, Tech. Paper **409**: 74 pp., 1928. From Chem. Abst., **22**: 3758, October 10, 1928. Affinity of coal for oxygen and other properties and conditions which underlie its tendency to heat spontaneously, erratic heating behaviour of coal in storage, and some common storage practices are discussed. Important results obtained in different countries during past 50 years through fundamental investigations on factors which influence spontaneous heating of coal are assembled and correlated with work carried out by Bureau of Mines, discussions being limited mainly to work done since 1900. Authors present these conclusions: All coals except anthracite undergo spontaneous heating. Chemical constitution of coal varies with its rank, and low-rank coals heat more easily than high-rank or older coals. Oxidation of coal substance itself is main cause of spontaneous heating, but no one constituent exerts preponderant influence. First stage in spontaneous heating is operative at room temperature as soon as freshly broken coal is exposed to air and consists in formation of solid compound of coal and oxygen. Second stage involves the decomposition of this compound and, with Appalachian coals, begins at about 85°F. and is completed at about 445°F. There is no sharp transition temperature from one stage to other and both processes go on simultaneously from about 85° to 445°F. Pyrite present in finely divided form is a contributory, but seldom the determining, chemical factor. Moisture other than that

needed for oxidation of pyrite is probably not chemical factor. Organic sulfur, ozone in air, and bacteria are not important practical factors. Most important physical factors are size of coal and initial temperature of exposure, provided sufficient oxygen is present to saturate the coal. Heat capacity and conductivity depend largely on moisture content and size of coal. Occluded gases probably have little effect. Suggestions made applying these conclusions to storage of coal: Special care should be exercised in storage of subbituminous coal. Coal containing fine pyrites should not be stored. Avoid segregation of fine coal in storage pile and carefully exclude foreign matter. Wetting down surface of pile changes its ventilation and may favor heating at points not reached by water. It is well to use temperature measurements to depth of at least 6 feet from surface of pile. In common practice 150°F. is considered as approaching danger point, but heating curve for coal is smooth one with no sharp breaks. Most fruitful studies of future will probably be those that deal with storage conditions, especially on effect of air supply. Nine-page bibliography containing over 200 references is included.—*R. E. Thompson.*

Combustion of Powdered Coal. B. Moore. Trans. Inst. Chem. Eng. (advance proof), March, 1928, 12–24. From Chem. Abst., **22**: 3759, October 10, 1928. Degree of fineness of powdered coal affects considerably its rate of combustion, ignition properties, and "combustible capacity," as determined by method previously described (C. A., **19**: 2398; **20**: 3553). Rate of combustion increases and "glow point temperature" falls with increasing degree of fineness. Results indicate that there is critical temperature and critical degree of fineness at which combustion of particles becomes almost instantaneous.—*R. E. Thompson.*

Some Experiences Gained in the Control of the Operation of Steam Boiler Plants. Gustav Edling. Svensk Pappers-Tid., **31**: 277–9, 1928. From Chem. Abst., **22**: 3759, October 10, 1928. Account of experiences gained in carrying out caloritechnical control of operation of steam boiler plants. Attention is particularly drawn to defects and unsatisfactory conditions frequently disclosed by this control.—*R. E. Thompson.*

Preliminary Boiler Tests with Preheated Air at the Sugar Mill Wonoaseh (Java). I. Hes and H. J. Spoelstra. Arch. Suikerind., **36**: III; Mededeel. Proefstat. Java-Suikerind., 535–62, 1928. From Chem. Abst., **22**: 3798, October 10, 1928. All tests showed increase in efficiency of boiler plant, without any operating difficulty. Owing to local conditions, preheater was placed in first flue and it was therefore not possible to investigate attainable cooling down of flue gases and increase in efficiency resulting therefrom.—*R. E Thompson.*

Tests of Clay and Concrete Load-Bearing Pipe. W. J. Schlick. Proc. Am. Soc. Testing Materials, 1928 (preprint 66), 12 pp. From Chem. Abst., **22**: 3754, October 10, 1928. Discussion of some of more common problems of test procedure, particular attention being given to problems encountered in

use of the two most common of the standard bearings, namely sand and three-edge, in tests of different sizes and classes of pipe and to necessity for controlling moisture and temperature of specimens if truly comparable test results are to be obtained. Real meaning and value of absorption test are discussed and certain common, but incorrect, procedures in drying and immersion treatments are pointed out. Freezing and thawing test is only direct durability test that has been standardized.—*R. E. Thompson.*

Clarification of Waste Tannery Liquors and Their Utilization for Agricultural Purposes. V. HLAVINKA. Sbornik Geskoslovenké Akad. Zemědělské, 2: 41–54, 1927. From Chem. Abst., 22: 3800, October 10, 1928. Inorganic constituents, with exception of compounds of chromium and arsenic, are usually harmless, and no danger is likely to arise from bacteria unless pathogenic types are present; these are only imperfectly removed by treatment with chlorine or bleaching powder. To obtain efficient sedimentation, tanning liquors should be kept separate from lime-pit liquors. Sedimentation is carried out in sand pits and in raking plants where chemical reactions are allowed to go to completion so that coagulation of suspended matter is accelerated. Slime obtained contains 98 per cent of inorganic and 75 per cent of organic solids suspended in liquors. Clarified liquors retain only 10 per cent of original chromium content. Slime has nitrogen content of 5–6 per cent, and after drying to water content of 60 per cent, may be used as fertilizer.—*R. E. Thompson.*

Description of a New Hydrogen-Ion Colorimeter. R. B. H. GRADWOHL. J. Lab. Clin. Med., 12: 694–701, 1927. From Chem. Abst., 22: 3901, October 20, 1928. Colorimeter consists of box with series of hermetically sealed special glass ampules containing sterile buffers of known pH value, latter being marked on metal strip running along top of rows, together with series of bottles of indicators. Illuminating box is furnished with arrangement for sliding back and forth along any one of rows of buffers which are taken from box for comparative purposes. Method of adjusting reaction of culture media is described.—*R. E. Thompson.*

The Fermentation of Glucose by B. Coli. ROSNATOVSKII. Centr. Bakt. Parasitenk., I Abt., 102: 145–8, 1927. From Chem. Abst., 22: 3902, October 20, 1928. Ratio of hydrogen to carbon dioxide in gases resulting from fermentation of glucose by *B. coli* has previously been given as 2:1. For various reasons this does not always hold. If medium is acid, the sodium hydroxide used in absorbing carbon dioxide from mixed gases will release more carbon dioxide. Also if bouillon is acid, 1 per cent glucose will give about twice as much gas as 0.5 per cent. With neutral bouillon the percentage of glucose makes little difference. When gas was analyzed by absorption of carbon dioxide with sodium hydroxide and explosion of residuum in eudiometer, it was found to be pure carbon dioxide and hydrogen. In acid media the hydrogen: carbon dioxide ratio varied from 6:1 to 10:1. In neutral media it was 2:1. Change from glucose to hydrogen and carbon dioxide goes by steps.—*R. E. Thompson.*

Methods of Evaluation of the Actual Reaction of Bog Waters. I. A. Smorodintzev and A. N. Adova. Bull. soc. chim. biol., **10**: 806–11, 1928. From Chem. Abst., **22**: 3906, October 20, 1928. Quinhydrone electrode method and method without buffer solutions are utilizable for determination of pH in acid bog waters. Nitrophenol series of indicators in determinations made in free air give results tending toward alkalinity. Reaction of bog water determined its flora; thus with pH 3.82 to 5.6 vegetation was largely *Sphagnum*, and with pH 7.4 to 8.47 vegetation was largely *Carex*. Bog waters with acid reaction were poor in flora and fauna and larvae of *Anopheles* were absent.—*R. E. Thompson.*

Determination of Hydrogen Sulfide in Sea Water. G. Drucker. Internat. Rev. Hydrobiol. Hydrogen., **16**: 130–3, 1926. From Chem. Abst., **22**: 3942, October 20, 1928. Sea water is run directly into 15 cc. of 0.01 N iodine solution acidified with 1–2 cc. concentrated hydrocloric acid.—*R. E. Thompson.*

Spent Gas Liquor in Relation to Sewage Disposal. H. Ross Hooper. Munic. Eng. Sanit. Record, **81**: 90–1, 1928. From Chem. Abst., **22**: 3943, October 20, 1928. Following absorbed oxygen values in p.p.m. (.0125 N potassium permanganate at 27° for 4 hours) are given: spent gas liquor from vertical retorts, 7500; from horizonal retorts, 4000. Some elimination of water may be effected by use of drier coal, acid scrubbers, and better control of steaming in vertical retorts. Oxygen absorbed value of dilute spent gas liquor (4000 p.p.m.) was reduced about 90 per cent by biological filtration at rate of 15 gallons per cubic yard per 8-hour day and further reduced to below 20 p.p.m. by a second filtration at rate of 12 gallons per cubic yard. Equalizing tanks to give even discharge of liquor into sewers is recommended. Lime particles usually present are precipitated.—*R. E. Thompson.*

Automatic Colorimeter. G. Baganz. Chem. Fabr., 1928, 358. From Chem. Abst., **22**: 4010, November 10, 1928. Apparatus is designed for control of chlorination of water by use of benzidine and potassium iodide as colorimeter indicators, but is capable of adaptation. It consists of electrical arrangement for taking of samples, addition of indicator and washing out of apparatus at regular time intervals, observation only being left to attendant.—*R. E. Thompson.*

New Colorimeter and Its Use. H. Kleinmann. Chem. Fabr., 1928, 263–4, 278–9. From Chem. Abst., **22**: 4010, November 10, 1928. Colorimeter is similar in principle to Duboscq instrument and consists of pair of vessels of 1 cc. capacity, dipping rods, lamps, scales, and eyepiece. For accurate results careful filtration of solution is necessary and air bubbles must be avoided. Errors then should not exceed 1 per cent. Instrument is suitable in conjunction with micro-Kjeldahl apparatus for determination of nitrogen by Nessler reagent. Quantities as low as 5×10^{-6} milligram can be determined, principal difficulty being not of manipulation, but in obtaining reagents sufficiently free from ammonia.—*R. E. Thompson.*

An Improved Orsat Apparatus for the Analysis of Flue Gases. KARL MÜNZER. Chem. Fabr., 1928, 518–20. From Chem. Abst., 22: 4013, November 10, 1928. "Mono" apparatus, very similar to HAYS portable apparatus, is described.—*R. E. Thompson.*

A Small Flue Gas Tester. A. GROSZ. Feuerungstech., 16: 163–4, 1928. From Chem. Abst., 22: 4013, November 10, 1928. Carbon dioxide apparatus described contains no liquid and one cock. After sample has flowed through apparatus, a turn of cock puts it in contact with lime. After turning over several times to mix lime and gas, reduction in pressure is read on diaphragm by making electrical contact through micrometer screw. Apparatus is $9 \times 9 \times 5$ centimeters.—*R. E. Thompson.*

Apparatus for the Analysis of Solutions, Especially Bleach Liquors Containing Chlorine. K. HINTZMANN. Chem. Fabr., 1928, 266–7. From Chem. Abst., 22: 4011, November 10, 1928. To determine available chlorine in bleach liquor, an apparatus comprising a graduated tube with lower reaction bulb and upper stoppered bulb holding 75 cc. liquid is used. Reaction bulb is filled with 75 cc. of a standard solution of indigo-carmine (1.46 grams of the 44/45 per cent powder and 2 cc. sulfuric acid per liter), stopper placed in upper bulb, apparatus inverted, and buret read. Whole is turned back to normal position and solution to be analyzed is added slowly until color of mixture changes from blue to light yellow-green. Stopper is replaced, apparatus inverted and buret read again to obtain volume of bleach liquor added.—*R. E. Thompson.*

The Best Material for Water Pipes in Buildings. A. BÖRNER. Apparatebau, 40: 196–8, 1928. From Chem. Abst., 22: 4014, November 10, 1928. In long run copper is cheaper and less troublesome than iron.—*R. E. Thompson.*

Methods of Corrosion Testing with the Aid of Indicators. HEINRICH THIELE. Korrosion Metallschutz, 4: 152–3, 1928. From Chem. Abst., 22: 4098, November 10, 1928. Initial progress of corrosion of metals can be followed by use of suitable indicators. Dyes which become colorless on reduction and ferric chloride-potassium ferricyanide solution in agar are suitable for non-ferrous metals. Ferroxyl indicator is used for iron. Since potassium ferricyanide is strong oxidizing agent, only small quantities are used in the agar. Metal is immersed, removed after short time, and exposed to hydrogen sulfide or ammonia vapors. In case of copper, corroded portions appear black or blue respectively.—*R. E. Thompson.*

The Rôle of Water in Hygiene. F. BOURGUIN. L'Eau, 21: 92, 1928. From Chem. Abst., 22: 4187, November 10, 1928. General discussion.—*R. E. Thompson.*

The Corrosion of Iron and Its Anodic Polarization. R. A. DENGG and H. J. DONKER. Korrosion Metallschutz, 3: 241–6, 1927. From Chem. Abst., 22: 4099, November 10, 1928. Current density-e.m.f. curves were obtained for 6 commercial irons of different compositions immersed in solution 0.1 N in

potassium chloride and 0.1 N in potassium carbonate to determine effects of composition on e.m.f. required to overcome resistance of protective film. The e.m.f. decreases with increasing carbon content. In light of theory of protective film formation in alkaline solutions, authors claim that possibility of having corrosion occur on iron depends upon composition of electrolyte. Upon immersing an anode in chloride-carbonate solution the current at constant e.m.f. falls off with time. Current has 2 functions, strengthening protective film and saturating inaccessible areas with oxygen. A minimum potential is required to start corrosion. If potential required is between those of oxygen and iron, corrosion can proceed. If potential required is higher than that for oxygen in same solution, no corrosion can take place. Since iron assumes potential imposed upon it by oxygen it is reasonable to suppose that impurities take on potential imposed by the oxygen. Hence most detrimental impurity is one which assumes highest potential. In case of iron the iron itself is dangerous. Authors assert that when in contact, the nobler of 2 metals is not always protected when immersed. If two be brought into contact in solution in which nobler has smaller penetration potential than the more base, then former will go into solution and latter will behave as cathode. In this case the nobler protects the more base. Noble metals are protected only when base metal can go into solution. Pitting is explained by weaknesses in protective film due to irregularities in structure of metal underneath. As soon as film is penetrated the metal goes into solution, decreasing the hydroxyl ion concentration surrounding point of attack, thus accelerating the corrosion. Corrosion occurs at slag inclusions only because of probable differences in structure of metal at slag boundaries. Fact that sodium hydroxide gives better protection than potassium carbonate is not due to hydroxyl ion concentration since in solutions of both having same pH potassium carbonate is far superior.—*R. E. Thompson.*

Regarding Corrosion Phenomena. XIV. With Reference to the Protective Effect in the Corrosion of Iron Under Steam Boiler Operating Conditions. A. THIEL and H. LUCKMANN. Korrosion Metallschutz, **4**: 169–77, 1928. From Chem. Abst., **22**: 4099, November 10, 1928. Description given of method of corrosion testing of iron by weighing water formed from hydrogen evolved on heating metal for extended periods of time in solutions at 100°. Iron was also treated in N sodium hydroxide solutions containing varying quantities of sodium carbonate, sodium chloride, sodium sulfate, or sodium phosphate, in presence of oxygen at 200° in autoclave. Weight increase of metal was measured after 2 hours. Hydrogen evolution data showed 0.01 N sodium hydroxide to be two-thirds as corrosive as distilled water and 0.05 N sodium hydroxide one-fourth as corrosive. Presence of air did not appreciably affect results. Weight increment data showed additions of sodium sulfate, chloride, and carbonate to accelerate corrosion increasingly, while sodium phosphate reduced it about 80 per cent. Corrosiveness of added salt depends on concentration. Conclusion regarding known protective influence of sodium sulfate is that in solutions in which concentration is great enough to form scale a protective film is precipitated and where solubility of sodium sulfate is not exceeded no protection can be expected. **XV. The Results of the Work on**

Corrosion in Darmstadt and Their Relation to the Investigation at Marburg. A. THIEL. Ibid., 177–8. Article comparing contemporary work of the 2 institutions on boiler water investigations.—*R. E. Thompson.*

Electrolytic Destruction of Pipes. W. B. MCCABE. Commonwealth Eng., 15: 475–7, 1928. From Chem. Abst., 22: 4098, November 10, 1928. Concluded that considerable destruction of pipelines is taking place electrolytically in Melbourne. Substitution of wood stave pipe suggested as possible remedy.—*R. E. Thompson.*

Titration of Carbon Dioxide in Water. L. SMITH and G. WODE. Z. angew. Chem., 41: 208–12, 1928. From Chem. Abst., 22: 4189, November 10, 1928. See Chem. Abst., 21: 3997–8.—*R. E. Thompson.*

Corrosion of Condenser Tubes. "Impingement Attack." Its Causes and Some Methods of Prevention. R. MAY and H. C. H. CARPENTER. J. Inst. Metals (advance copy), No. 471, 35 pp., 1928. From Chem. Abst., 22: 4100, November 10, 1928. Introduction by CARPENTER reviews work of the Corrosion Research Committee. This investigation deals with effect of intermittent cavitation of entering water and of air bubbles on deterioration of condenser tubes. Behaviour of protective films was studied by measurement of "film potentials." Experiments showed that air bubbles alone could cause impingement attack. Size of bubbles is important, very small bubbles producing only slight attack. Methods of preventing impingement attack described, including elimination of rotary motion in water boxes, use of grids to reduce cavitation and use of resistant materials. Of latter, 70:30 cupronickel and 2 per cent aluminum brass are recommended. Small increase in carbon dioxide content of water may remove protective scale from tubes. Also in Engineering, 126: 309–12, 1928.—*R. E. Thompson.*

Corrosion at Discontinuities in Metallic Protective Coatings. ULICK R. EVANS. J. Inst. Metals (advance copy) No. 467, 33 pp., 1928. From Chem. Abst., 22: 4100, November 10, 1928. Hot-dipped, electrodeposited, sprayed, and sherardized zinc coatings on steel were exposed to various types of atmospheric and submerged corrosion tests, including immersion in tap water. Other metallic coatings were also investigated. Conclusions: Cracks in coatings produced by bending cause enhanced corrosion of anodic coatings or of base metal in cathodic coatings. In immersed corrosion rust is precipitated outside of coating while in atmospheric corrosion rust precipitates underneath and pushes coating away from steel. Zinc protects exposed steel spots by sacrificial corrosion and hence thick coating is beneficial even though it cracks worse. Zinc builds up protective coating in atmospheric corrosion but not in submerged corrosion. Aluminum coatings are less attacked than zinc but gives no protection at cracks when immersed in Cambridge water. Also in Engineering, 126: 407–8, 1928.—*R. E. Thompson.*

Effect of the Nature of Peptone on Eijkman's Fermentation Test. J. DE GRAAF. Nederland. Tijdschr. Hyg. Microbiol. Serol., 3: 22–38, 1928. From

Chem. Abst., 22: 4143, November 10, 1928. It has been observed that water of Maas River gave fermentation in Witte's peptone (W), but not in Poulenc peptone (P), Pure colon cultures gave fermentation in both. Difference between peptones was not attributable to initial difference in pH (W, 6.5; P, 5.3), although controls showed that initial pH of 5.0 prevented fermentation. Nor was it the end pH, which was always 4.6–4.9, with or without fermentation. It was caused by additional acidity produced by streptococci which were present in river water and which developed better in P than in W. This was already indicated by more rapid decrease in pH in P (after 6 hours: 4.5 in P, and 5.5 in W). Inhibiting action on *B. coli* of these acid-producing streptococci was partly counteracted by gelatin-liquefying bacteria also present in the water providing they were sufficiently numerous. These bacteria grew in W only.—*R. E. Thompson.*

Bacteriophage Phenomena in the Case of a Water Bacterium, *B. Cloacae Szegediensis Crystalliformans*. A. v. JENEY. Centr. Bakt. Parasitenk., I. Abt., 102: 263–8, 1927. Chem. Abst., 22: 4144, November 10, 1928. Above bacterium was isolated from sewage-contaminated water. Bacteriophage was found in culture filtrates.—*R. E. Thompson.*

A Method of Selective Enrichment for Parathyphoid in Water and Feces. FRIEDRICH HODER. Centr. Bakt. Parasitenk., I. Abt., 102: 313–9, 1927. From Chem. Abst., 22: 4144, November 10, 1928. Addition of malachite green (between 1:5000 and 1:10,000) to medium consisting of 10 per cent bile in bouillon favors growth of paratyphoid bacilli.—*R. E. Thompson.*

Tentative Method for Complete Sand Analysis. Glass Ind., 8: 217, 1927. From Chem. Abst., 22: 4744, November 20, 1928.—*R. E. Thompson.*

Hydrogen-Ion Studies of Water, Peat, and Soil, in Relation to Ecological Problems at Bacon's Swamp, Marion Co., Indiana. STANLEY A. CAIN. Proc. Indiana Acad. Sci., 37: 395–401, 1927. From Chem. Abst., 22: 4151, November 10, 1928. Water samples should be tested for pH value in field, as rapid changes are induced by respiratory-photosynthetic relations of microorganisms present.—*R. E. Thompson.*

Investigation of the Capacity of the Evaporating Surface and the Steam Space of Steam Boiler and Evaporating Apparatus. CHR. EBERLE. Arch. Wärmewirt., 9: 282–3, 1928. From Chem. Abst., 22: 4185, November 10, 1928. Quality of steam produced by boiler at pressures from 1 to 10 atmospheres was found to depend on volume of steam evolved per hour, not on its weight. Moisture in steam became appreciable at certain critical volume and rose rapidly and linearly thereafter.—*R. E. Thompson.*

Insulation Against Heat and Cold. I. S. CAMMERER. Chem. Fabr., 1928, 318–20. From Chem. Abst., 22: 4185, November 10, 1928. Estimates of thermal losses from steam pipes, etc., with and without insulation are given. All insulating materials depend on porous structure with air spaces, but if

spaces are not quite small, convection currents are set up. Qualities desirable for insulating materials for various purposes described. Variety of materials are used for heat insulation, but only cork and peat have been used for cold insulation. Practical tests are of partciular value in choosing insulating material.—*R. E. Thompson.*

A Method for Determining the Percentage of Water in Steam. ROBERT AVICE. Rev. agr. Maurice, 5: 124–5, 1928. From Chem. Abst., 22: 4185, November 10, 1928. Sampling pipe 1 inch in diameter and perforated in several places is mounted in steam line in such manner that samples may be taken at any desired moment. Weighed quantity of water is placed in convenient receptacle, and steam from sampling pipe passed through it for several minutes. Receptacle is reweighed, and percentage of dry steam, q, may be calculated from following formula: $W(T_2 - T_1) = W_1(qL + (T_3 - T_2))$, where W is original weight of water; W_1, the weight of condensed steam; T_1, the initial temperature of the water; T_2, its final temperature; T_3, the temperature of the steam; and L the latent heat of the steam. For greater accuracy, heat absorbed by receptable must also be considered; then formula changes to: $(W + SW_2)(T_2 - T_1) = W_1(qL + (T_3 - T_2))$, where W_2 is weight of receptable, and S, the specific heat of material from which it is made. "Throttling calorimeter" may be used for same purpose as method described, but it is expensive.—*R. E. Thompson.*

The Chemico-Sanitary Investigation of Water with Regard to Organic Substances. L. M. HOROWITZ-WLASSOYA, A. M. and F. M. GOLDENBERG. Arch. Hyg., 98: 234–40, 1927. From Chem. Abst., 22: 4187, November 10, 1928. Investigation was made of river water, of infusions of dry and green leaves, and of various solutions of proteins, fats, and carbohydrates. Similar values obtained by KUBEL'S reaction for the oxidizability of the solutions did not correspond to identical content of organic matter. A 0.01 per cent solution of glucose takes up in 10 minutes only 75 per cent of calculated amount of oxygen; peptone under same conditions scarcely 25.5 per cent. Method of FOWLER is of greater value from sanitary point of view, since organic material of animal origin is more rapidly determined by this method.—*R. E. Thompson.*

Measurement of the Quality of Water. JACK J. HINMAN, Jr. Proc. Iowa Acad. Sci., 34: 69–75, 1927. From Chem. Abst., 22: 4680, November 20, 1928. Review and discussion with bibliography.—*R. E. Thompson.*

Present Practice in Water Meter Construction. DENKERT. Gas u. Wasserfach, 71: 778–84, 804–9, 1928. From Chem. Abst., 22: 4187, November 10, 1928. Present day construction, resistance to corrosion, and working range of German water meters are discussed in detail, with illustrations—*R. E. Thompson.*

The d'Herelle Bacteriophage in Drinking Water. PAUL FABRY. Rev. Hyg. Med. Prev., 50: 667–71, 1928. From Chem. Abst., 22: 4187, November 10, 1928. Absence of *B. coli* may not indicate pure water as organism may

have undergone lysis by bacteriophage and be unrecoverable by ordinary laboratory methods. If a bacteriophage is found in water, this may indicate *per se* intestinal pollution.—*R. E. Thompson.*

Expansion of the Municipal Waterworks at Bologna. A. NATALE. Gas u. Wasserfach, 71: 799–804, 1928. From Chem. Abst., 22: 4188, November 10, 1928. Details of expansion of Bologna waterworks given, particularly as regards chemical feed and filtration.—*R. E. Thompson.*

Some Recent Improvements in the Softening of Natural Waters. P. PATIN. Chimie et industrie, Special No., 158–62 (April, 1928). From Chem. Abst., 22: 4188, November 10, 1928. Descriptions and discussion of water softening with artificial zeolites.—*R. E. Thompson.*

Experiences with the Norit Filter in Tropical Countries. J. W. WOLFF. Geneeskund. Tijdschr. Nederland. Indie, 68: 171–82, 1928; cf. WOLFF, Centr. Bakt., I. Orig., 101: 163, 1927. From Chem. Abst., 22: 4188, November 10, 1928. When used for filtration of clear well water the Norit filter yielded sterile water at rate of 1–2.5 liters per hour. One Norit filling may last 6 months. Turbid, heavily contaminated river water soon clogs pores of chamber which serves for retention of coarse impurities.—*R. E. Thompson.*

Influence of Free Chlorine on the Elimination of Manganese from Water. O. WEBER. Chem.-Ztg., 51: 794–5, 1927. From Chem. Abst., 22: 4189, November 10, 1928. Elimination of manganese from water by aëration and filtration depends more on biological than chemical action. Tabulated results from water works of Hanover show that manganese content is not reduced by aëration and filtration when chlorine is added to raw water. Considerable improvement is obtained when chlorine is added after filtration, but manganese is not entirely removed except when unchlorinated water is used for washing coke filters. Filters require time to attain highest efficiency. Manganese dioxide present in filter is important.—*R. E. Thompson.*

Engineering Methods Economically Combat Stream Pollution (Treatment of Acid Waste from Brass Cleaning). W. L. SULLIVAN. Chem. Met. Eng., 35: 483–5, 1928. From Chem. Abst., 22: 4191, November 10, 1928. Acid waste from brass cleaning, containing nitric and sulfuric acids equivalent to 0.3 per cent by volume, may be treated by allowing it to react with iron shavings, but product is objectionable in color. Treatment with limestone, as adopted, gives clear colorless effluent which is not acid to methyl orange. Flow of 50,000–80,000 gallons per day is treated in 3 wooden tanks containing 0.75–1.0-inch dolomitic limestone and fourth containing 0.25–0.5-inch high-grade limestone. Flow is downward through first 2 tanks to permit skimming of calcium soap and upward through last 2. Dilution to 0.3 per cent sulfuric acid is provided. To prevent coating limestone, soapy water is diverted to sanitary sewer. Crystallization of calcium sulfate is prevented by draining each night, use of dolomitic limestone and dilution. Water is run for 2 hours after plant operation ceases. Stone is then flushed and sludge discharged to sedimentation basins.—*R. E. Thompson.*

Identification of Oil-Field Waters by Chemical Analysis. C. E. REISTLE, Jr. Chem. News, 137: 101–2, 1928; cf. C.A., 21: 2518. From Chem. Abst., 22: 4192, November 10, 1928. Chemical analyses may assist in identifying water from different strata in oil fields.—*R. E. Thompson.*

Theoretical and Experimental Studies on the Scaling of Boilers. R. STUMPER. Chimie et industrie, 20: 10–20, 1928; cf. C.A., 21: 3998. From Chem. Abst., 22: 4191, November 10, 1928. Critical review of work done on, and theories proposed to explain, mechanism of formation of boiler scale, particularly from standpoint of physicochemical laws governing formation of solid phase in solutions.—*R. E. Thompson.*

The Heat Conductivity of Boiler Scales. CHR. EBERLE and CL. HOLZHAUER. Arch. Warmewirt., 9: 171–9, 1928. From Chem. Abst., 22: 4191, November 10, 1928. Heat conductivity tests were made on dry compressed powders of varying densities, composed mainly of either silica, calcium carbonate or calcium sulfate, also on solid slabs of 2 latter. Material makes very little difference, conductivity depending almost wholly on density. Study was made of 31 samples of scale collected at random. Calcium sulfate scale had always high density and silicate a low density. Calcium carbonate was usually dense. Silica layer 0.02 centimeter thick may do as much harm as dense calcium sulfate layer 0.4 centimeter thick. Photomicrographs of scale and discussion of possible modes of formation included.—*R. E. Thompson.*

The Contraction of Cements. J. COCAGNE and Y. MATRAS. Ciment, 33: 232–4, 1928; Science & Industrie, 12, 89–94. From Chem. Abst., 22, 4219, November 10, 1928. Best results are secured by using as little water in mix as possible followed by copious wetting after cement has reached its set, by applying rather lean mixes, and probably by using sharp aggregtates.—*R. E. Thompson.*

Action of Distilled and River Water on Tensile Strength of Cement Test Briquets. ALTON J. BLANK. Rock Products, 31: 14, 66–7, 1928. From Chem. Abst., 22: 4219, November 10, 1928. There was no retrogression in strength when briquets were stored in distilled water, whereas retrogression is common when calcareous river water is used for storage.—*R. E. Thompson.*

Determination of Available Sulfur in Mineral Waters. CHARLES LEPIERRE. Chimie et industrie, Special No., 131–2, April, 1928. From Chem. Abst., 22: 4189, November 10, 1928. Available sulfur is defined as that present as H_2S, XHS or X_2S. Because of lack of sensitiveness of ordinary methods of determination, absence of available sulfur has often been reported in waters in which it could be detected by its odor. Determination by production and colorimetric determination of thionine gives accurate results for amounts varying from few milligrams to few hundredths of milligram of sulfur per liter. Followng technic ecommended: To suitable amount of water (up to 2 liters) add 1 cc. concentrated hydrochloric acid, then 0.05 gram p-phenylenediamine,

and finally 0.2 cc. of 10 per cent ferric chloride, mix, heat to about 60°, let stand until color has reached maximum intensity (about 15–20 minutes) and compare with standard thionine solution. Commercial thionine can usually be employed for preparing standard solution; but if shade differs appreciably from that obtained with sample, solution of hydrogen sulfide should be standardized iodometrically, suitably diluted and treated as above. Reaction is specific, being unaffected by sulfites, thiosulfates or the alkalinity of the water.—*R. E. Thompson.*

Possibilities in the Development of Supplementary Powdered Coal Burners. W. GUMZ. Feuerungstech., **16**: 41–3, 1928. From Chem. Abst., **22**: 4229, November 10, 1928. Calculation shows that fine grinding greatly increases capacity of supplementary powdered coal installations; coarse particles do not burn on grate, as was formerly supposed. Advantage should be taken of properties of powdered coal by increasing radiant heat absorption and by preheating the air.—*R. E. Thompson.*

Soft Water in the Kier Boil. S. F. ALLING. Am. Dyestuff Rept., **17**: 558, 1928. From Chem. Abst., **22**: 4256, November 10, 1928. Soft water should always be used in kier boil for removal of fats and waxes.—*R. E. Thompson.*

A Conductance-Diffusion Method for Studying the Coagulation of Colloidal Ferric Oxide. C. H. SORUM. J. Amer. Chem. Soc., **51**: 1154, 1929. The author considers that much of the confusion in coagulation studies is probably due to faulty technique. Earlier methods for studying the coagulation of colloids gave inaccurate results, because of difficulty in determining the exact point of coagulation. Workers on this subject have come to the conclusion that coagulation is accompanied by adsorption of the coagulating ion. Therefore, at the point of coagulation, the concentration of the electrolyte should decrease abruptly. Experimentally this can be shown by a break in the time-resistance curve, plotted by means of the conductance method of measuring electrolytic concentration. The practical problem is to find a suitable method of adding the electrolyte, gradually and uniformly, to prevent any preliminary coagulation. This can be done either by evaporation or by slow diffusion through a membrane. Breaks in the curve were obtained by the evaporation method, but it was very slow and required eight hours constant attention. A conductance-diffusion cell was constructed, consisting of two platinum electrodes suspended in a colloidon bag containing the sol, submerged in a solution of the electrolyte. The electrolyte was added slowly to the solution during diffusion so that the concentrations on both sides of the colloidon bag remained about the same. The critical coagulation concentration was changed by the rate of addition of the electrolyte. This method does not, therefore, give quantitatively exact measurements, but the results are comparative. Interference with diffusion by the floc and not adsorption of the electrolyte may be the cause of the break in the time resistance curve.—*M. H. Coblentz (Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature).*

Reduction Potential, Energy Exchange and Cell Growth. Experiments with B. Coli. J. H. QUASTEL and W. R. WOOLDRIDGE. Biochem. J., 23: 115, 1929. Experiments were conducted on the anaërobic growth of *B. coli* in a lactate fumarate medium to which was added: (*a*) succinate, which is activated by the same enzyme as fumaric acid; (*b*) an -SH compound (cysteine, glutathione, thioglycollate), which is independent of the cell for its reducing action and can act in a homogeneous phase; and (*c*) formate, which is dependent on the cell for its reducing action but is independent of the lactate-fumarate enzymes. The succinate inhibits the anaërobic growth of *B. coli*, probably by competing with the fumarate for its enzyme, or part of the effect may be due to its securing a high reduction potential in the cell. In the case of cysteine etc., the growth is inhibited; but with formate the growth is accelerated; although both effects are due to the reducing power of the respective substances. The authors feel justified in concluding that the rate of growth of *B. coli* is not dependent on the oxidation or reduction intensity of its environment. Relatively high concentrations of these substances do produce a similar inhibitory action on the anaërobic growth of *B. coli* and it is possible that with these concentrations certain limiting conditions are secured above which growth cannot take place. For these conditions it is probably not so much the magnitude of a reduction potential which is of significance as the activity or reducing power responsible for the potential i.e., the considerations are kinetic rather than potential.—*M. H. Coblentz* (*Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature*).

Use of Iron Reagents in the Detection and Differentiation of Phenols. A. H. WARE. Quart. J. Pharm., 1: 377, 1928. The Analyst, 54: 58, 1929. There are three classes of phenols; (*a*) those giving only one definite color reaction with ferric salts; (*b*) those having two or more hydroxyl groups and giving color changes with ferric chloride largely determined by pH concentration; and (*c*) those containing pyrone and quinonoid phenols and giving with ferrous salts and weak alkali an intense brown color. MITCHELL'S reagent (0.1 gm. ferrous sulphate and 0.5 gm. Rochelle salt in 100 cc. of water) is used with decreasing pH and ferric chloride with increasing pH. MITCHELL'S reagent (Analyst 1923, 48: 2) has a pH near 7; ferrous or ferric hydroxides, basic ferric acetate, or phenol-iron-complexes may be eliminated, but the controlled precipitation of certain complexes may be brought about when necessary. Maximum intensities of color for classes (*b*) and (*c*) may be obtained by adjusting the pH. The reagent is added until no further darkening occurs, and the pH adjusted with very dilute ammonia or sodium bicarbonate solution. If a negative result is obtained, the phenol is placed provisionally in class (*a*); a violet color indicates class (*b*) and a deep brown class (*c*). Potassium acetate is then added, the mixture boiled, and tannin is precipitated, also haematoxylin (blue), maclurin, and many anthoxanthins, as brown complexes. For the ferric chloride test, a 1 per cent so-called neutral solution is added, drop by drop, to the solution of phenol; the results with various phenols are described. For another special test, a small quantity of phenol is dissolved in 5 to 10 cc. of water with a little ferrous sulphate, one drop of 10-volume hydrogen peroxide

added, and the mixture shaken until a definite color, green, red, or brown, is given. The mixture is then shaken with from 0.2 to 0.5 gm. of sodium sulphite. Results are as follows:

Name of Phenol	*Color before adding sodium sulphite*	*Color after adding sodium sulphite*
Carbolic acid, the cresols	Deep green	Blue, violet, or purple
Guaiacol and B.P.creosote	Brownish green	Blue, violet, or purple
Salicylic acid, etc.	Purple	Brown
Thymol and eugenol	Not distinctive	Not distinctive
Hydroquinol	Reddish color	Blue, violet, or purple
Resorcinal and orcinol	Brown	Blue, violet, or purple
Phloroglucinol	Yellow, greenish, or brown	Brown, or yellow
Aloin and phloridzin	Brown, or reddish	Brown

A test for isocarbon is described. A drop of hydrogen peroxide is added to from 5 to 10 cc. of a filtered solution of aloes in water and, after shaking, 1 per cent ferric chloride solution, drop by drop, shaking after each drop; color changes will be: green → brown → ruby red → reddish purple. A precipitation test for certain phenols is carried out in 5 stages with MITCHELL'S reagent, or a solution of citrate of iron and ammonia, and Rochelle salt, ammonium hydroxide, 35 per cent acetic acid, and a 35–40 per cent solution of formaldehyde as subsidiary reagents. Details and results are tabulated. There are defined stages at which pure gallo-tannins, phlobatannins, and phenols of class (*b*) are precipitated and pyrogallol tannins are distinguished.—*M. H. Coblentz* (*Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature*).

Zeolite Water Treating System of the Beacon Street Heating Plant. J. H. WALKER and LEO F. COLLINS. Ind. Eng. Chem., 21: 1020–4, 1929. Softening of a moderately hard water by use of zeolites, followed by sulfuric acid neutralization, is practical. The cost of this treatment is somewhat higher than normal, but is justified, in consideration of the increase of steam obtained therewith. Interesting diagrams of the system are given.—*Edward S. Hopkins* (*Courtesy Chem. Abst.*).

Thawing Out: Winter Water-Works Problems. J. WALTER ACKERMAN. The American City, 41: 5, 97, November, 1929. Watertown, N. Y., utilizes a locally constructed electrical equipment for thawing services, a Ford engine being employed to drive a specially constructed alternating current generator which has a capacity of from 0 to 75 volt and from 0 to 500 amperes. This equipment may be placed on a three-ton truck and transported to any part of the city. Current of 200 or 250 amperes usually thaws a house connection in about ten minutes. This work is done free of charge by the city because most of the connections were laid years ago at insufficient depth. If, however, the pipe is exposed on private property, such as open cellars or areaways, then a charge of five dollars is made. Special hydrant inspection and maintenance services are maintained in cold weather.—*Chas. R. Cox.*

Building a Dam near Pike's Peak Timber Line. JOSEPH C. DOYLE. The American City, 41: 5, 107, November, 1929. A brief description of a dam of one of the storage reservoirs in the City of Colorado Springs, Colo., located on the slopes of Pike's Peak.—*Chas. R. Cox.*

A Survey of Water-Meter Rates in the United States, Part VI. The American City, 41: 5, November, 1929. Part VI of a tabulation prepared by The American City from data collected from The Municipal Index.—*Chas. R. Cox.*

Beauty Added to Utility in Elevated Water-Tank. PAUL HANSEN. The American City, 41: 5, 136, November, 1929. A description is given of an elevated tank in Highland Park, Ill., which is surrounded by an outer ornamental structure because of its location in a residential section. The cost of the tank was $34,200 and that of the enclosing structure $54,440.—*Chas. R. Cox.*

Water-Main Cleaning Unearths an Antique. The American City, 41: 5, 139–140, November, 1929. While 10,000 feet of 12-inch and smaller mains in the downtown section of St. Louis were being cleaned, an old stop valve constructed in 1839 was discovered.—*Chas. R. Cox.*

Diesel-Engine Pumping Equipment is Both Economical and Reliable. The American City, 41: 5, 159–161, November, 1929. This is Part III of a digest of pamphlets issued by municipal water departments and private companies relative to the regulation of water taps and services.—*Chas. R. Cox.*

Scout Dike Reservoir. A Development by Barnsley Corporation. Anon. Water and Water Engineering, 31: 367, 301–303, July 20, 1929. Additional information with regard to certain details in the construction of this reservoir is given. Further description of the outlet tunnel, valve tower, reservoir overflow, devices for measuring all flow from reservoir, and materials, such as stone and clay, used in construction, are included.—*Arthur P. Miller.*

Report on the Proposed Heightening of the Aswan Dam. Anon. Water and Water Engineering, 31: 367, 304–309, July 20, 1929. To determine the feasibility of raising the Aswan dam, the Egyptian government appointed an international commission to investigate and report on the matter. Four questions were referred to it:—(1) *Whether it was advisable to heighten the existing dam to the levels required?* After a very careful investigation of the dam, particularly with reference to cracks in the present masonry, to erosion on the sluice culverts and their aprons, to the integrity of the bond between the original dam and the first addition to it, and to whether there was upward pressure on the aprons below the sluices, the commission concluded that the dam could be heightened as much as nine meters. (2) *Whether any designs submitted were suitable and, if so, which one?* The commission set forth the conditions to be fulfilled by a design for this work and then, under them, decided that no proposal made was satisfactory. (3) *If no design at hand was suitable, the commission was requested to prepare one.* A general outline with some drawings of the commission's suggestions is given. (4) *Whether proposals for hydro-*

electric developments at dam which modify it in any way will affect safety of raised structure? The commission opposed any such project which necessitated piercing the solid portion of the dam.—*Arthur P. Miller.*

The Water Shortage Memorandum by Ministry of Health. Measures Adopted by Wakefield's Water Engineer. Anon. Water and Water Engineering, 31: 367, 309–310, July 20, 1929. Abnormally low rainfall throughout England and Wales (except southern district of Cornwall) produced a real shortage of water early this year. The Ministry of Health took cognizance of the condition by issuing a memorandum drawing attention to the necessity for preventing waste, the diversion of compensation water into the public supply when possible, use of alternative supplies such as non-potable ones for street washing and the like, restriction of supplies, and the necessity for added care in controlling the purity of the water. At Wakefield (England) it finally was necessary to shut off water from 6 p.m. to 6 a.m.; but this was done only after other measures had been introduced to conserve water to the utmost.—*Arthur P. Miller.*

The Hydrology of the Portsmouth District. D. Halton Thomson. Water and Water Engineering, 31: 367, 313–317, July 20, 1929. The writer gives a full discussion of the hydrology of the Portsmouth (England) district in the topography of which one of the most important elements is the South Downs. The article is rather of specific interest to those particularly interested in that locality. Among the broad subjects discussed are geological conditions, rainfall, evaporation, the underground water system, intermittent streams (locally named lavants), springs in that area, and local water resources.—*Arthur P. Miller.*

The Desirability of River Gaugings for Various Purposes. E. A. Sandford Fawcett. Water and Water Engineering, 31: 367, 317–319, July 20, 1929. This paper is a plea for more interest and action in procuring accurate data on the river flows in England. In spite of past activities along lines related to water, there is very little reliable information on the flow of water in rivers and it does not appear that any will be forthcoming immediately, because a Technical Sub-Committee of the Water Advisory Board, Ministry of Health, has reported that a national organization for river gauging is not warranted in view of cost, labor, and time involved. The Commission suggests, though, that considerable data can be obtained by the use of existing agencies. The various purposes for which gaugings are needed are set forth as water supply, industry and power, floods, dilution, and navigation.—*Arthur P. Miller.*

Skegness Urban District Council. Opening of Pumping Station Extensions, Welton. Anon. Water and Water Engineering, 31: 367, 319–320, July 20, 1929. In 1910, a 14-inch boring was made to supply water. During 15 years' use, a large quantity of sand had been drawn from it; but now this condition obtains only when the pumping rate is suddenly increased. To augment this water supply, it was decided to make the most of the existing boring by connecting it with a heading at depth of 125 feet to a 12-foot well. This provides ample space for collecting and removing sand. Further, additions to this

supply can now be made by new borings connected by adits to the large well.—*Arthur P. Miller.*

The Water Supply of Gibraltar. W. H. PEARCE. Water and Water Engineering, 31: 367, 325–326, July 20, 1929. Two classes of water are supplied; potable and brackish. Gibraltar is almost rainless for five months in the year; there are no springs, streams, or wells; and for defence reasons, the water supply must be within the fortress. The results of this condition are artificial rain water catchment areas and storage reservoirs in tunnels within the heart of the rock. Reservoirs now available hold 8¼ m.g. and a new one is under construction to hold an additional 5 m.g. The catchment areas are 15 acres of steep natural rock and 23 acres of artficial area made by placing corrugated iron sheets on creosoted piles on a 35° slope. Due to ravages by the white ant, piles on eight acres are to be replaced with new ones of teak. The construction of the new reservoir and work on such steep catchment areas introduce special difficulties, on some of which the writer touches. The town is supplied by gravitation from the reservoirs and the water quality is checked weekly in a laboratory. Brackish water is procured from wells sunk in the neutral territory and pumped to various service reservoirs. Pipes, valves and meters are very quickly encrusted and eaten away.—*Arthur P. Miller.*

The Cladothrix Dichotoma and Allied Organisms as a Cause of an "Indeterminate" Taste in Chlorinated Water. B. A. ADAMS. Water and Water Engineering, 31: 367, 327–329, July 20, 1929. One of the tastes produced by chlorination can only be called "indeterminate." This term includes tastes like those described as mouldy, earthy, froggy, and peaty. The author had his first experience with tastes of this kind while working with water from the Nile River. Taste troubles which he faced led to an investigation of means to combat them and of the causative agent. From his work he concluded that the mould-like taste was due to the presence or past-presence of *Cladothrix dichotoma* or of certain species of streptothrix, which give off volatile products; that chlorination, especially in small doses, will accentuate the taste and may even develope it at times when it cannot be detected in the untreated water; and that none of the chemicals usual in water treatment can entirely prevent or remove this taste.—*Arthur P. Miller.*

Experimental Studies of Natural Purification in Polluted Waters. III. A Note on the Relation Between Food Concentration in Liquid Media and Bacterial Growth. C. T. BUTTERFIELD. Public Health Reports, 44: 47, 2865–2872, November 22, 1929. Test organism used was *Bact. aërogenes.* In series of media having food materials concentration as the only variable, multiplication took place for 48 hours, usually, then remained fairly constant. An increase in concentration of food materials resulted in increased limiting numbers of bacteria, but not proportionally. The apparent mathematical relationship between maximum numbers of *Bact. aërogenes* (y) and concentration of food supply in milligrams (x) is, $y = 2.29, x^{0.813}$, in the range 2.5 to 1,000.0 mgm. In a medium containing one-half the minimum concentration of food material to permit growth of *Bact. aërogenes* without extensive lag, a small sewage

coccus grew abundantly, but *Bact. bütschlii*, approximately ten times larger than *Bact. aërogenes*, did not grow well. *Bact. bütschlii* multiplied satisfactorily, however, in a medium containing ten times that concentration. *Colpidium*, a bacteria eater, grew vigorously in a medium containing 5,000 mgm. of food material per liter; failed to grow in pure culture at concentrations less than 500 mgm. but flourished at 5.0 mgm. concentration in the presence of *Bact. aërogenes*. The author states "These observations suggest an orderly relationship between the size of the individual cell and the minimum concentration of available food which will support growth; that is, the larger the individual, the greater the concentration of food required. The hypothesis is also suggested in the case of the protozoon *Colpidium*, growing in combination with bacteria, that the bacteria act as accumulators or concentrators of the too dilute food."—*R. E. Noble.*

Court Decision Relating to Public Health. Damages Awarded for Death from Water-borne Typhoid Fever. Indiana Appellate Court; Pennsylvania R. Co. et al. *v.* Lincoln Trust Co., 167 N. E. 721; decided September 16, 1929.) Public Health Reports, **44**: 47, 2874–75, November 22, 1929. "In 1903 a connection was made between Fort Wayne's potable water supply and the Pennsylvania Railroad's supply of river water, a swinging valve and two gate valves being installed to prevent the pollution of the city water by the river water. In its opinion, the appellate court stated that, 'The gate valves on each side of the swinging valve were open, and the jury was justified in finding that the swinging valve would not seat so as to prevent water from the river flowing into the city water main.' "—*R. E. Noble.*

Gulls as Sources of Contamination of Water. ALEXANDER HOUSTON. The Medical Officer, **42**: 1106, 153, October 5, 1929. An account is given of gulls covering the reservoirs, of the Metropolitan Water Board, in such great numbers as to make it appear as if the water had been covered with vast blankets of snow. Arrangements were made for the firing of guns to frighten the birds away each evening and at other periods, if necessity arose. The results proved to be most encouraging. The water in the reservoirs was in such a bad condition bacteriologically as the result, presumably of the gulls' visits, that chlorination of the water was started. An investigation has been carried out to see if any positive results indicating the presence of the typhoid bacillus could be obtained from the "droppings" of gulls on the Board's works. Although typhoid bacillus was not isolated, it was found that the "droppings" of gulls contain at least one million *B. coli* per gram weight. It was also found that each gull may contribute 50 to 100 million *B. coli* per day to a waterworks.—*A. W. Blohm.*

The Relation of Topographic Mapping and Water Resources Investigations to the South's Industrial Progress. THORNDIKE SAVILLE. Reprint from Proc. Industrial Development Conference, Southern Division of The American Mining Congress, Atlanta, Georgia, April 11–12, 1929. The writer has been a constant student of the trends in the development and use of the water resources in the Southern Appalachian region throughout the period of industrial

expansion. He surveys the present state of these resources and indicates the importance of beginning at once systematic studies of the fundamental hydrological phenomena upon which a large part of the future industrial and municipal expansion must be predicated. Many southern communities have had problems in the past because of lack of basic data on: rainfall and stream flow; evaporation and silting of impounding reservoirs; economic feasibility of reforestation of drainage areas; flood control; stream pollution by domestic sewage and trade wastes and analyses of stream waters. The Division of Water Resources and Engineering of the North Carolina Department of Conservation and Development has classified its work into general projects as follows: general; stream gauging; power studies; hydrologic investigations, hydrologic surveys; coasts, ports, waterways; stream sanitation and conservation; chemical water analysis; drainage; underground water investigations, and mapping. In carrying out work under these projects the Division utilizes existing agencies of the Federal Government, State, municipalities or industries. It is pointed out that the states for which no state funds are available for stream gauging are industrially the least advanced of the Southern States. The writer considers an accurate topographic map as a supreme basic necessity in all problems of water resources and modern regional planning involving studies of topography, rivers, airports, highways, water supply, sewers, transportation, water power, recreation, industrial location, etc. "The Temple Act passed by Congress in 1925 provides for 50 percent of the expenses of topographic mapping of states to be met by appropriations to the U. S. Geological Survey which does the work, the other 50 percent to be contributed by the states. Congress has never appropriated sufficient money to meet state needs, but this is due largely to apathy on the part of many states in urging larger federal appropriations to meet their contributions and in voting state coöperation."—*A. W. Blohm.*

The Composition of Water and Mosquito Breeding. WILLEM RUDOLFS and JAMES B. LACKEY. American Journal of Hygiene, 9: 1, 160, January, 1929. An attempt has been made to correlate the chemical composition of water and the biological growth contained in it with the abundance of mosquito breeding. Two definite pools were selected, one, which has bred mosquitoes for a number of years and another in which, according to records, no breeding or only sparse breeding occurred. In connection with this study C. pipiens larvae were introduced into rain water and waters collected from certain drainage areas. In certain cases the reaction of the water was artificially changed and suitable food added.

It appears that specific substances either present in the water or produced by the decomposition of vegetable matter may be responsible for the growth of microörganisms and subsequently for the breeding of mosquitoes.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abst.).*

Schistosomiasis and Malaria in Relation to Irrigation. J. F. C. HASLAM. Empire Marketing Board Publication 17, May, 1929, London, England. This is a review of the prevalence of these diseases in irrigated sections of the globe. Schistosomiasis caused by a trematode worm having certain water snails as

one necessary intermediate host is closely linked up with human waste disposal and incidentally methods for the elimination of snails from irrigation works are discussed. A short summary of the well known relation to malaria of irrigation is given. Where rainfall is under 20 inches per year irrigation will probably be proposed and both these diseases being closely associated with water are likely to gain a foothold when the irrigation works are constructed. The importance of foreseeing this in new and large irrigation projects is stressed. Excellent maps are included showing the world wide endemic regions of the two diseases and their geographical location.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abst.).*

The Effects of Storage Upon The Quality of Water. A. GORDON GUTTERIDGE. Health, Commonwealth of Australia, 5: 2, 33, March, 1927. A discussion of the origin of surface and ground water from rainfall; the factors influencing the quality of these waters as they pass over land surfaces or through soil formations and the effects of storage on the quality of surface waters.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abst.).*

Value of Water Works Maps and Records. E. J. STEWART. Proc. Seventh Annual Water Works School, University of Lawrence, Kansas. 81. The charge is made that privately operated water plants keep adequate records, maps, and prints of the plant, but publicly operated plants usually have no plans or maps and very meager records. The article lists the important records which should be kept by the operators.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abst.).*

Illinois Mobile Water and Sewage Laboratory. ANSELMO F. DAPPERT and HARRY F. FERGUSON. Public Health, 20: 1, 80–84, January, 1930. The Engineering Division of the Illinois State Department of Health, placed a mobile milk laboratory in operation in 1927. This has proved so successful that a second laboratory for use in the control of water purification and sewage treatment plants and in the study of stream pollution in the state has recently been completed. A 21-passenger, street-car type, Dodge Bros. motor bus was purchased and equipped at a cost of $5,900. Equipment includes the apparatus necessary for the following determinations: odor, color, turbidity, ammonia nitrogen, nitrates, nitrites, alkalinity, acidity, pH, chlorides, free chlorine, iron, dissolved oxygen, oxygen consumed, B. O. D., bacterial counts at both 20° and 37°, and *B. coli* counts; also for microscopical examinations. Dual wiring circuits are provided; one for 6-volt current either from the battery system on the chassis, or from a special rectifier and battery system fed by 110-volt A. C. current, is utilized for ceiling lights, fan, heating elements in incubators, etc.; the other, designed for 110-volt current, serves additional ceiling lights, 12 service outlets, fan, movable electric room-heaters, heating element in the 37° incubator. The 110-volt circuit can be used when current is available at water or sewage treatment plants and may be easily connected by means of a 100-foot reel of insulated wire and feed plug. Running water is available from a 30-gallon tank suspended from underneath the car frame below the laboratory floor. Water and air piping connections extend through the

bus body and may be easily reached. Air under pressure is secured through a tire valve on the air line at any gasoline station. A special tank is also provided for temporary storage of waste sink water. Folding cots are carried for two people for occasional use, such as during 24-hour tests, or in disaster relief work.—*C. R. Cox.*

Tuscaloosa Secures an Unpolluted Water Supply. GEORGE J. DAVIS, JR. The American City, 42: 1, 111-2, January, 1930. The water supply of Tuscaloosa, Alabama, was secured previously from Black Warrior River, upon which the city is located. This river is subject to pollution incidental to river traffic, sewage from over a quarter of a million population on the watershed, and a large amount of industrial wastes, including phenolic wastes from by-product coke ovens. It was abandoned as a source of supply and Little Yellow Creek was developed at cost of $350,000. Dry weather flow of the stream, which has a watershed of 30 square miles, is said to be adequate for present needs of the city. A storage reservoir with capacity of one billion gallons will therefore afford ample supply for large industrial use for many years to come. The water from the creek is not seriously polluted, is very soft, and low in mineral content. A conventional rapid sand filtration plant has been constructed. The main dam is a true arch structure, 64 feet high and 330 feet long.—*C. R. Cox.*

Stream Pollution an Indictable Offense. SCOTLAND G. HIGHLAND. American City, 41: 6, 117-118, December, 1929. The city of Frankfort, Ind., was recently sued by a property owner because of the discharge of sewage from the city into Prairie Creek. The city contended that it had a right to discharge raw sewage into the creek. The court held, however, that this was not the case, as the discharge of untreated sewage into the creek constituted a menace to health, and that such discharge was not necessary, because the sewage could be treated in a practical and economical manner. The author points out that there is a common opinion that the pollution of lakes and rivers is a legitimate practice in the absence of specific statutes prohibiting it. This is not the case, however, as the common law has long held that pollution of streams so as to injure riparian rights may be restrained by injunction. It is likewise emphasized that the problem of preventing the pollution of streams by industrial wastes is one for the various industries to study, as their chemists and engineers have an intimate knowledge of the character of the wastes and of the processes involved in the industry. The author considers that the various states should require the installation of waste and sewage treatment plants, as otherwise there will be little correction of the present undesirable conditions where accessible streams are seriously polluted, making it necessary for municipalities to go to distant sources for water supply at correspondingly greater cost.—*C. R. Cox.*

Flexibility of Operation Possible at New Saginaw Water-Works. ALFRED ECKERT. The American City, 41: 6, 141-143, December, 1929. The water supply of the City of Saginaw, Michigan, is secured from the Saginaw River, following storage in Lake Linton which forms a natural storage reservoir.

A new softening and filtration plant embracing many interesting details has recently been completed. All of the pumping machinery is electrically driven and gate valves are electrically operated. Reserve power is provided by two generators, each driven by 875-H.P. Fulton diesel engines. These engines may be placed in service in not more than five minutes. A very unusual feature is the provision of a group of 125-volt storage batteries for emergency use in lighting the plant and in operation of the gate valves on the discharge side of the high pressure pumps in case of power failure. Another unusual feature is the use of a central gate house, through which the effluent of the Dorr clarifiers, settled and carbonated water, and filtered water pass. This provides great flexibility and permits the by-passing of certain units as well as the possibility of chlorinating the water at any of the three stages in the purification process. Incidentally, a portable chlorinator is provided for miscellaneous use. The raw water is dosed with alum, soda ash, and lime through six dry feed, chemical dosing machines. Bucket conveyors handle lime and soda ash in bulk. Four mechanically operated agitators are provided for mixing the chemically treated water. The coagulated water flows to two Dorr clarifiers, the effluent from which flows to two large covered settling basins of three million gallons capacity which may be operated in parallel or in series. Settled water is carbonated with carbon dioxide generated by a coke burner equipped with scrubber and drier. Six conventional rapid sand filter units with a capacity of two million gallons per day each are utilized. The clear well has a capacity of 400,000 gallons and a nine-million-gallon covered filter water reservoir is also provided. The plant is equipped with a complete chemical and bacteriological laboratory.—*C. R. Cox.*

The Behavior of a Reinforced Concrete Arch During Construction. S. B. Slack. Proc. Am. Soc. Civ. Eng., **55**: 9, 2279–99, November, 1929. The author presents the results of measurements on a 160-foot span reinforced concrete arch of a bridge near Eatonton, Ga. The measurements were to determine the behavior of an open-spandrel concrete arch rib. They were started while the concrete was being placed and continued until about one month after the bridge was completed. The work included measurement of strain in steel and concrete, of vertical movement of the arch rib at the crown, of movement of abutements, of temperatures at various points in the arch rib, and of movements in expansion joints in the decks. The observations indicate that the arch ribs began rising and falling with the varying atmospheric temperature between the third and fourth day after the concrete work had been completed. Allowance made for temperature stresses in the design of concrete arches should be based on a fall of temperature and no allowance should be made for rise in temperature. There was no measurable movement of the abutments. The observed stresses in the steel and concrete were consistently higher than the computed stresses.—*John R. Baylis.*

Past Experience with High Dams and Outlook for the Future. A. J. Wiley. Proc. Am. Soc. Civ. Eng., **55**: 9, 2318–26, November, 1929. The author concludes that masonry dams on suitable bedrock are safe and permanent structures. An arched gravity type of masonry dam has a larger factor of safety

than a straight gravity dam of the same section. The contraction joints of an arched gravity dam do not prevent arch action. The stability of an arched gravity dam is increased as the radius of curvature is shortened. There is no uplift in the body of a concrete dam except that caused by horizontal joints, nor in foundation rock which is free from seams. Seepage through concrete may be detrimental and should be remedied.—*John R. Baylis.*

Classification, Selection, and Adaptation of High Dams. D. C. HENNY. Proc. Am. Soc. Civ. Eng., 55: 9, 2327–36, November, 1929. The heights of some of the highest dams are given. The highest earth dam built to date is 233 feet above bed stream, but one now under construction will have a height of 245 feet. A rock fill dam 300 feet high is under construction, and a masonry gravity dam 350 feet above the base was completed in 1929. Of the single arch type, there is one now under construction that will be 400 feet above the base. Foundation requirements for various types of dam are discussed, and sources of danger are considered.—*John R. Baylis.*

Construction Methods and Plant Layout at Coolidge Dam, in Arizona. J. G. TRIPP. Proc. Am. Soc. Civ. Eng., 55: 9, 2347–56, November, 1929. The contractor for the Coolidge Dam on the San Carlos Project, Arizona, was faced with unusual difficulties as to plant selection and choice of handling methods. The author discusses the layout of the concrete plant, the excavation plant, general service problems, and the construction work.—*John R. Baylis.*

Effect of Turbulence on the Registration of Current Meters. D. L. YARNELL and F. A. NAGLER. Proc. Am. Soc. Civ. Eng., 55: 10, 2611–40, December, 1929. The author describes experiments conducted on several types of current meters to determine the effect of turbulence on their registration. The tests were made by holding the meters stationary in controlled streams of water. The author concludes that a flowing stream may be so turbulent as to change noticeably the readings obtained by a current meter. The cup meter overregisters and the screw type underregisters in a turbulent flow.—*John R. Baylis.*

NEW BOOKS

Rohr Brunnen. ERICH BIESKE. München: R. Oldenbourg. Cloth; 6¼ × 9½ inches; pp. 214. 14 marks. Reviewed in Eng. News-Rec., 103: 625, October 17, 1929.—*R. E. Thompson.*

Standard Specifications for Concrete and Reinforced Concrete. Canadian Engineering Standards Association, 178 Queen St., Ottawa. Paper; 6 × 9 inches; pp. 149. Reviewed in Eng. News-Rec., 103: 467, September 19, 1929.—*R. E. Thompson.*

Steam and Gas Engineering. A Text Covering Power Generating Apparatus Utilizing Energy Released by the Combustion of Fuels. THOMAS E. BUTTER-

FIELD. New York: D. Van Nostrand and Co. Cloth; 6 × 9 inches; 481 pp. $4.50. Reviewed in Eng. News-Rec., 103: 821, November 21, 1929.—*R. E. Thompson.*

The Oxyacetylene Welder's Handbook. A Complete and Practical Manual of Modern Practice. M. S. HENDRICKS. Chicago: The Acetylene Journal Publishing Co. Flexible; 4½ × 6½ inches; pp. 208. $3. Reviewed in Eng. News-Rec., 103: 822, November 21, 1929.—*R. E. Thompson.*

The Story of Water Supply. (The City and Country Series.) HOPE HOLWAY. New York and London: Harper and Bros. 5 × 8 inches; 134 pp. $1.25. Reviewed in Eng. News-Rec., 103: 823, November 21, 1929.—*R. E. Thompson.*

Annual Report 1926-27, Dominion Water Power and Reclamation Service, Dept. of Interior, Ottawa, Canada. The total hydraulic installation to date is 4,556,266 h.p., of which 265,838 h.p. was installed in 1926. Projects under way will add over 1,700,000 h.p. and others in active prospect indicate a further addition of 1,000,000 h.p. The latter two items involve a capital expenditure of about $270,000,000.—*M. H. McCrady.*

Pacific Drainage, British Columbia and Yukon Territory. Water Resources Paper No. 53: 1927. Dominion Water Power and Reclamation Service, Dept. of Interior, Ottawa. Surface Water Supply data for the climatic year ending Sept. 30, 1926.—*M. H. McCrady.*

Arctic and Western Hudson Bay Drainage. Water Resources Paper No. 54: 1928. Dominion Water Power and Reclamation Service. Dept. of Interior, Ottawa. Hydrometric investigations for the climatic year ending Sept. 30, 1926.—*M. H. McCrady.*

Water Powers of Manitoba. Water Resources Paper No. 56: 1926. Dominion Water Power and Reclamation Service, Dept. of Interior, Ottawa. Administration, developed power and available undeveloped power.—*M. H. McCrady.*

Arctic and Western Hudson Bay Drainage. Water Resources Paper No. 57: 1929. Dominion Water Power and Reclamation Service, Dept. of Interior, Ottawa. Hydrometric investigations for the climatic year ending Sept. 30, 1927.—*M. H. McCrady.*

Metropolitan Water Board, London, England. Twenty-third Annual Report on the Chemical and Bacteriological Examination of the London Waters for the Twelve Months ended 31st December 1928. Sir ALEXANDER HOUSTON. The report contains a mass of information relative to the treatment, purification, and laboratory examination of the London waters. The subject of the River Thames as a source of supply, is dealt with at length. The river is 210 miles long and its watershed embraces 5,405 square miles. The average daily abstraction for waterworks purposes is limited to 150 million Imperial gallons daily.

Chlorination of Thames water has now reached its 13th year. Readers are reminded that chlorine was first introduced for water sterilisation in England by the author as far back as 1905, when it was used at Lincoln in combating an epidemic of typhoid fever. Over 26,141 million gallons of Thames river water were treated with 0.42 parts per million of chlorine at a cost of 17.6 cents per million gallons. The estimated saving in coal by water chlorination in lieu of storage and repumpage was equivalent to $29,440. The quality of water was excellent and not a single complaint of taste was received. Since chlorination was introduced, there has been a marked increase in the number of million gallons of water filtered per acre of filter beds cleaned. In the worst case, that of Kempton Park, the increase was from 28.1 to 31.47 millions and in the best, at West Middlesex, from 35.25 to 67.40 a rise of 32.55. As it costs $200 per acre of filter bed, for cleaning, the saving is very considerable. The last remaining calcium hypochlorite plant was replaced during the year by a liquid chlorine plant. Chlorination of the New River supply was practised when found necessary. It is asumed that if chlorination was not practised, increased storage and filtration area would be required, consequently the treatment is regarded as a means of saving money and conferring additional safety. As this supply is subject to taste troubles, preventive treatment consisting of the addition of ammonia and permanganate prior to filtration is practised. Over 5,481 million gallons of water received treatmeent which cost a total of 46 cents per million gallons. Close upon four years experience has been gained in the use of primary filters at some of the works in easing the work and so prolonging the life between successive cleanings of the slow sand filters. The primary filters worked at an average rate of 141 gallons per square foot per hour (146.92 million imperial gallons per acre per day). In the past it had been difficult to maintain the West Middlesex supply during periods of active algal development. This condition has been greatly relieved by primary filtration. At Walton, the water is first stored in reservoirs, after which it passes through primary filters to slow sand units operated at a greatly accelerated rate of filtration. The effluent is then treated with ammonia and chlorinated. The water as finally delivered in the mains contained no *B. coli* in 100 cc. in 96.4 per cent of samples examined. The number of million gallons filtered per acre by the slow sand system reached the remarkable average of 576. The quality of pre-filtration waters is permanently recorded by means of micro-photographs which show the type and nature of suspended matter present. The laboratory album now contains 15,000 pictures taken over a period of 13 years. A special study was made of the new WILSON and BLAIR medium for the isolation of the typhoid bacillus from liquid and solid matters. In the search for the paratyphoid group, 1,590 colonies were isolated from 159 specimens, but not a single one was shown to belong to this grouping. Regarding the WILSON BLAIR medium, Sir ALEXANDER HOUSTON states "At certain seasons of the year the medium, in common with other media, has yielded disappointing results; but speaking generally, the method advocated marks a great advance in the technique of bacteriology. The medium allows the bacteriologist to work with a much larger amount of material (without overcrowding the plate cultures) than previously, and therefore enhances the probability of capture of the typhoid bacillus. Applying the test to the raw water, it has been possi-

ble, on more then one occasion, to isolate a microbe indistinguishable from the true *B. typhosus*. These isolated positive results point to the extreme importance of not relinquishing any of the purification safeguards hitherto employed. On the other hand, by contrasting artificially inoculated (in known amount) with non-inoculated samples of river water, the results have gone to show, on inferential grounds of reasoning, that Thames water is safer usually than could otherwise have been conjectured." Included in the miscellaneous section are a variety of subjects which include green growths in New River supply, the isolation of paratyphoid from sewage, the January floods in England, emergency chlorination as a result of the floods, cholera investigations, and gulls as a source of contamination of water. In discussing the green growths in the New River at Stoke Newington, it is shown that the introduction of copper sulphate to the water was not only useless but actually made the condition worse. The use of chlorine in large quantities helped to improve the quality of the water, as also did hydrated lime. Later on the organism disappeared, and was replaced by *Scenedesmus* which was found to be present in almost pure culture. The water in the reservoirs was unsatisfactory from a filtration point of view for several months. The January floods caused a deal of worry on account of the water rising to new levels, involving the safety of part of the London supply. As a result the filtered water was chlorinated at the valve house. Chlorination was carried out in seven places with completely successful results both as regards quality and lack of taste. For several years past, the question of gulls, as sources of contamination of water, has been dealt with in the Water Board reports. This year's report states that laboratory investigations indicated that the droppings of gulls contain at least one million *B. coli* per gram weight (equivalent to 0.0353 ounces). Special studies were made and it was found that the droppings of two gulls amounted to 157 grams in twenty-four hours. This means that each gull may per day contribute 50 to 100 million *B. coli* to a water-works. The bio-chemical investigations showed that no typhoid organisms were isolated from 626 colonies studied. As a result of an abnormal visitation of gulls at one of the works, the raw water had to be chlorinated for precautionary purposes. The systematic firing of guns for frightening the birds away proved encouraging. The report concludes with detailed tables of chemical and bacteriological analyses of the London waters, and includes miscellaneous information, hydraulic equivalents and conversions.—*N. J. Howard.*